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SECONDARY IMPACTS OF TRANSPORTATION AND WASTEWATER INVESTMENTS: REVIEW AND BIBLIOGRAPHY

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SECONDARY IMPACTS OF TRANSPORTATION AND WASTEWATER INVESTMENTS: REVIEW AND BIBLIOGRAPHY

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The Bibliography contains a review of over fifty major studies and three hundred relevant reports related to secondary environmental impacts on various forms of public investments, e.g. land based transportation and wastewater collection systems. The Bibliography is organized into four sections:

Section I is subdivided into: (a) a review of secondary impacts classified according to type of investment (highways, mass transit, and wastewater collection systems); (b) where possible, according to type of secondary effects (economic, social and land use); and (c) a brief summary of modeling techniques which may be utilized to analyze and project likely secondary environmental impacts.

Section II condenses the findings of about fifty major studies related to land transportation and wastewater treatment systems.

Section III is an annotated bibliography of about three hundred relevant studies.

Section IV classifies these literature studies by: (a) impact; (b) investment; (c) geographic area examined; (d) type of study; and (e) type of analytic techniques used in assessing secondary effects.

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SECONDARY IMPACTS OF TRANSPORTATION AND WASTEWATER INVESTMENTS: REVIEW AND BIBLIOGRAPHY

by

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Foreword

The widespread use of environmental impact analysis as a means of achieving Federal agency decision-making responsive to environmental concerns was initiated by the passage of the National Environmental Policy Act of 1969. The Act requires that Federal agencies prepare statements assessing the environmental impact of their major actions significantly affecting the quality of the human environment and indicates a broad range of aspects of the environment to be surveyed. The Council on Environmental Quality in guidelines for the preparation of environmental impact statements, dated August 1, 1973, states that many major Federal actions, in particular those that involve the construction or licensing of infrastructure investments such as highways and sewer systems ". . . stimulate or induce secondary effects in the form of associated investments and changed patterns of social and economic activities." Such secondary effects may in turn produce secondary environmental impacts even more substantial than the primary environmental impacts of the original action itself. The influence of highways on development decisions has been extensively researched. It appears that new sewer facilities are becoming increasingly more predominant in determining where development will occur, and this relationship has been much less investigated.

During the last eighteen months, the Council on Environmental Quality, the U.S. Environmental Protection Agency, and the U.S. Department of Housing and Urban Development have sponsored a study of the secondary effects of these two important types of public investments which stimulate land development - land transportation systems and wastewater collection and treatment systems.

The first part of the study, reported in this publication, involved a comprehensive review of previous research and literature dealing with the impacts of highways, mass transit, and sewers on residential, commercial and industrial development. The second part of the study involves the development of the tools which may be utilized by a variety of professionals, technicians, and laypersons in estimating land use development which may be expected to be stimulated by new land transportation and sewerage facilities. The results of this latter effort are expected to be published by the Council on Environmental Quality.

The project is being conducted by the Environmental Impact Center, 55 Chapel Street, Newton, Massachusetts, 02158 under the directorship of Dr. A. C. Makrides. The work was co-sponsored by the Ecological Impact Analysis Staff, Washington Environmental Research Center, U. S. Environmental Protection Agency; the Office of Policy Development and Research, U. S. Department of Housing and Urban Development; the Council on Environmental Quality. EPA is publishing this document in an effort to make the study results more widely available in order to improve the analysis of secondary effects, and to stimulate further research on this most important issue.

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U. S. Environmental Protection Agency

Abstract

The Bibliography contains a review of over fifty major studies and three hundred relevant reports related to secondary environmental impacts on various forms of public investments, e.g. land based transportation and wastewater treatment and collection systems. The Bibliography is organized into four sections:

Section I is subdivided into: (a) a review of secondary impacts classified according to type of investment (highways, mass transit, and wastewater treatment systems): (b) where possible, according to type of secondary effect (economic, social and land use); and (c) a brief summary of modeling techniques which may be utilized to analyze and project likely secondary environmental impacts.

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Section IV classifies these literature studies by: (a) impact; (b) investment type; (c) geographic area examined; (d) type of study; and (e) type of analytic techniques used in assessing secondary effects.

Preface

In the autumn of 1912, the Office of Public Roads summarized the findings of a definitive study, the full text of which was never released, on the advantages to farmers of better roads (1). The publication helped overcome rural opposition to a national road building program and hasten federal aid for roads under Congressional Acts in 1913 and 1916. The preface to the summary is worth quoting:

> So intimately are the public highways connected with every aspect of community life that almost any method devised to measure the benefits of good roads is incomplete. It is apparent, however, to anyone who has studied road matters for a period of years that the advantages of improved roads have been repeatedly proved beyond all argument. There is no case on record where any community has ever regretted the improvement of its roads . . . . When the various ways in which good roads benefit a community are examined, a complex situation is found in which many actions and reactions take place. When good roads reduce the cost of hauling, adjacent land becomes more valuable; there is a corresponding tendency of population to increase; and, in its turn, this tendency strengthens the demand for more good roads; social conditions improve; and the life of the community is influenced in numerous ways.

The summary gave a long list of potential benefits. As Reinsberg (1) points out, few of these were realized in any form resembling original expectations. However, notwithstanding these and other disappointments, it would be unjust not to acknowledge the long term highway benefits which were not illusory. "The expectation that farmers 'with the labor-saving devices and good roads could make a living on the farm without drudgery . . . and that they could enjoy some of the fruits of life besides making money on the farm' was amply fulfilled. Suburbanization was in some measure a realization of the hope, expressed in 1903, that 'good roads would carry the town to the country and the country to the town, preserving the blessings of both'" (1).

The impact of roads, and of other major public investments, has remained controversial since the pioneering study of 1912. Our understanding of the issues has undoubtedly improved, but basic problems remain unresolved (2)(5). This state of affairs is in part testimony to the difficulty of assessing accurately social and economic effects of major public projects. It is also a reflection of special circumstances surrounding research in this field. Traditionally, economists and social scientists have considered transfer of benefits in broad terms; accordingly, little research was done on localized impacts. Agency planners were concerned primarily with fulfilling public needs perceived in engineering terms. Studies carried out over the intervening years reflect these attitudes. The majority of impact studies were commissioned by agencies responsible for development; some of these studies come dangerously close to special pleading.

Despite such shortcomings, the results of impact studies carried out over the last few decades, particularly in the 50's and 60's, are still useful today. The main findings of previous work are summarized in the pages to follow. The contents of over fifty publications are also presented in condensed form. These studies were particularly helpful to us during the course of a project aimed at quantifying, to the extent possible, social and economic impacts of major facilities.

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SECTION 1

SECONDARY IMPACTS OF HIGHWAYS, MASS TRANSIT, AND INTERCEPTOR SEWERS - A REVIEW

Introduction

Three broad categories are commonly used in analyzing secondary effects: economic change, social and demographic change, and land use change. Within each category, many variables or indicators may be used to measure specific environmental impacts.

Economic secondary effects have received by far the most attention, primarily as a result of concern over economic benefits on economic dislocations caused by investments. A more general reason is the desire of sponsoring agencies to identify financial benefits as a justification for their projects. Variables used to measure economic impacts include changes in employment, sales, number of businesses, capital investment, and land or property values. Economic impacts associated with businesses are usually subdivided by type of firm -- manufacturing, trade or commerce, services, and other, more detailed categories.

Social and demographic effects include changes in population size and characteristics, and other, more subtle, changes in social interactions among individuals and groups. Population characteristics that may change include age structure, income and skill levels, and racial or ethnic mix. A substantial amount of research has been done on relatively abstract social impacts, such as, community cohesion and stability, neighbor linkage, and community values. So far, most of the effort has been aimed at developing quantitative measures for social impacts; less has been done in applying these measures to specific investments.

Land use changes are derivative to economic and demographic impacts, both of which imply some conversion in the use of land. Almost every economic or demographic change of consequence involves a land use change as well. Transportation and waste water investments affect people and businesses primarily by influencing their location decisions. Changes in locational decisions are reflected, in turn, in altered land use patterns. Changes in the amount of residential, industrial, commercial, agricultural, and vacant land are general measures of land use impacts.

Secondary impacts can be evaluated at a variety of geographic scales, ranging from the Nation as a whole to a small parcel of land at a highway interchange. Effects on land use, however, are usually considered in terms of relatively small areas.

The review of the literature given here is organized according to type of investment (highways, mass transit, waste water), and where possible, according to type of secondary effect (economic, social, land use). This classification reflects the nature of the literature. A brief summary of general modeling techniques which can be used to project and analyze likely secondary effects of major public investments is also given.

I. Highways

A. Economic Impacts

1. Geographic Distribution.

Economic impacts of improved highways include effects on the national economy, influences on regional rates of growth, and relatively localized effects within a single metropolitan area.

On a national level, improved transportation aids general economic development, since it improves the necessary transfer of goods and people between and within production and consumption centers. Transportation is also a consumption good in itself. In the particular case of the United States, the manufacture, operation, and servicing of automobiles and trucks is a fundamental part of the national economy.

In assessing the overall impact of an improved highway system (e.g. the Interstate System) on the economy of the nation, it must be borne in mind that in an already developed country, new transportation investments of essentially standard technology, alter mobility and relative costs only marginally. Accordingly, such investments do not have a profound influence on the growth or distribution of national economic activity (I-A-24). On a national scale, the main indirect economic impact of the improved highway was probably the added impetus it gave motor vehicle travel. Better highways were one more reason why the shipment of goods shifted from rail to highways.

On a regional basis, the impact of highways on economic growth appears to be minimal. The economy of the United States, which may be regarded as comprised of complementary regional economies, has been mobile and adaptable to competitive economic factors. The most significant trends in manufacturing locations over the last several decades were rapid growth in the South and West and comparative loss in the Northeast (6). Important factors in this change were climate, labor, and the availability of raw materials. Climate, to be sure, did not change over this period. However, climate was important in the growth of aircraft manufacturing and subsidiary industries in the West and in the Southwest, in the locations of military establishments, and in migration, especially of older people.

Improved highways did not play a significant role in the migration of industry out of the Northeast, nor in the more even geographic distribution of manufacturing employment throughout [illegible] country. Generally, location of manufacturing plants bears some relation to availability of raw materials, labor, transportation, and power. However, as noted above, new transportation investments in a developed country alter relative costs only marginally. Accordingly, highway improvements had a marginal influence on regional differential economic growth.

In a few specific instances, highway improvements appear to have been significant for particular locational changes. For example, the rise of motor trucking helped put the South in closer relation to population centers in the North and made possible the relocation of certain aspects of apparel manufacturing to the South. Similarly, some shifts of manufacturing from New York City to nearby areas of lower labor costs were facilitated by highways (6).

A generalized impact of highways on manufacturing growth of relatively small cities (10,000 to 50,000 population) may be inferred from a statistical analysis of about 100 "city pairs" consisting of cities matched in most aspects (geographic location, population, economic base), but differing in location with respect to the Interstate Highway System. Nationwide, there was no significant difference in growth rates for the two types of cities. In areas with dense population and uneven terrain, e.g., Northeast, Southeast, Pacific Northwest, cities on the freeway system grew faster (I-A-67).

Regional impacts of improved highways have been analyzed in connection with the public policy issue of using investments in transportation as a means for aiding economically distressed areas (I-A-27, 36,43,71). A strategy of highway development was followed in a number of instances (I-A-43,71); however, the preponderance of evidence suggests that regional development brought about by highways is slight (I-A-36,71) or moderate at best (I-A-43); other factors carry much greater weight in determining economic well-being of a region (I-A-27, 36,43,71).

Smaller areas, e.g., satellite cities, can sometimes be helped by new highways. There is evidence that economically distressed cities, if they are near a major metropolitan center, benefit from increased accessibility through "spillover" of industry, suburban residents, and service industries (I-A-27). The effect appears to be highly localized; it has occurred when the distressed city is within easy commuting distance of a metropolitan center (I-A-27), but not for somewhat more distant cities (I-A-27).

Local effects of highways are more substantial than regional effects. The bulk of detailed studies summarized below deals with the impact of highways on intraregional locational decisions of various types of industrial and commercial enterprises.

2. Business Location in Relation to Highways.

a) Manufacturing.

A series of studies, based mostly on interviews and questionnaires, assessed the importance of highways in site selection by industry (I-A-04,06,33,34,50,59). In general, industrial location decisions occur at three separable and sequential levels: (1) primary - selection of a broad region; (2) secondary - a narrowing of the decision to one or a few communities within the region; and (3) tertiary - actual site selection. Three main types of selection factors are involved: cost, market access, and non-economic considerations. Highway transportation is typically a cost factor at the tertiary level (I-A-34).

Accessibility to highways is one of a number of factors generally considered in site selection by most industries (I-A-06,33,34,50,59). The network of existing roads, rather than any one highway, appears to be important (I-A-34). Manufacturing industry will not, in general, pay a premium or sacrifice other elements of desirability in order to gain a highway site.

b) Wholesale and Retail Trade.

Distribution firms and wholesalers are generally more sensitive to highways than manufacturing establishments. Typically, these firms are concerned with proximity to a highway network adequate for serving their markets; they do not, as a rule, require direct access or direct exposure to a highway (I-A-59).

Warehousing, wholesaling, and some service industries have historically occupied locations within the CBD "frame," that is, in an area surrounding the CBD and characterized primarily by linkages to the broader metropolitan area (I-A-29). The development of extensive highway networks around and through metropolitan regions appears to have encouraged migration of such firms to more suburban locations.

Retail establishments are generally highly sensitive to highway location. Certain categories of retail businesses have a direct and intimate relation to roads and are described as "highway-oriented." These include service stations, motels, restaurants, and drive-in establishments of diverse kinds.

Retail business in cities appears to be spatially ordered with respect to the road network (I-A-26). Two basic conformations are evident: string street development and clusters. The latter are hierarchically structured from central business districts to neighborhood facilities. Additionally, retail establishments tend to be spatially associated with each other. In particular, a group of business types which tend to co-locate on "automobile rows" can be identified (I-A-26); another group of highway-oriented businesses are successful only when located on urban arterials or on highway strips (I-A-26).

The relative competitive position of the CBD against suburban shopping centers appears to have been weakened by improvements in the highway network of most metropolitan centers (I-A-70). Indirect effects of highways on the CBD are considered in greater detail below.

c) Services.

Finance, insurance, real estate, government and other services (e.g., medical services) have been traditionally concentrated in the central core of metropolitan areas and have been the most intensive users of commercial office space. The location of services is not, in general, sensitive to highways. However, some decentralization of services occurred as the population shifted to the suburbs.

Banking is primarily a "downtown" activity. In any given metropolitan area, total deposits in distance bands from the CBD core are inversely related to distance from the CBD (I-A-29). Most banks located in outlying areas of urban centers are found on or near state or Interstate highways. This is probably a coincidence and is indicative of an attachment of banks to commercial districts on these routes rather than to highways (I-A-29).

The insurance industry has decentralized significantly from the CBD core and frame. Insurance offices in suburban locations are generally in areas of comparatively dense residential settlement rather than in less built-up, unincorporated areas. Generally, suburban insurance offices are adjacent to major arterials or within a mile of a major arterial (I-A-29).

3. Highway Impacts on Cities.

Metropolitan areas generally consist of one or more central cities, secondary industrial and commercial centers, older suburbs of increasing population density, and peripheral suburbs mainly of single-family detached homes. About 40 percent of the national population lives in large metropolitan centers, each with population of one million or more.

Metropolitan population and employment have been decentralizing rapidly. In spite of continuing efforts to strengthen central cities, many have lost population, even after repeated annexations. According to the Census of 1970, employment outside the central city in SMSA's with population of 250,000 or more was slightly over 50 percent of the metropolitan total (7).

Decentralization of population and employment followed different historical patterns. Population moved to the suburbs first; employment followed. In recent times (1960-1970), rising rates of suburban employment and slowed population growth in the suburbs have brought the two into balance.

The role of the automobile (and of highways) in the exodus to the suburbs was probably that of a catalyst rather than of a causative factor. Almost universal dependence on automobiles characterizes peripheral suburban areas where heaviest growth is taking place. The trends observed in employment dispersion suggest that automobiles and motor trucks had a specific impact on relocation of certain types of business.

a) Manufacturing.

Central cities lost and suburbs gained employment in manufacturing over the last twenty years. In the period 1948-1963, there was a loss of 600,000 jobs in the 24 largest central cities and a gain of about 1,000,000 jobs in the suburbs (I-B-20). In terms of percentages, manufacturing employment in the central cities decreased from 67% of the SMSA total in 1948 to 53% in 1963. It dropped below 50% by the 1970 census.

The findings of specific local studies, e.g., Route 128 in the Boston Metropolitan Area (I-A-05), suggest that the move from city to suburb was generally helped by new circumferential and radial highways. Most "new" industries in the suburbs are industries relocating from the central city (I-A-04,05).

b) Wholesale and Retail Trade.

Wholesale trade, typically a CBD frame activity, migrated steadily and significantly to suburban locations. Wholesale employment in the suburbs was negligible in the immediate postwar years (1948); by 1963, it accounted for about 40% of suburban jobs. In overall percentages, central cities dropped from about 90% of the SMSA total in 1948 to 72% in 1963 (I-B-20). Dependence on over-the-road trucking increased steadily over this period.

There is little doubt that the Interstate highway network, including circumferential belts, played an important part in the decentralization of wholesale trade activity (I-A-29). Specific locational studies of wholesale establishments support this conclusion (I-A-59).

Retail trade in central cities dropped consistently and sharply from 1948 to 1970, roughly from three quarters of the SMSA total to less than half (I-B-20). Case studies (I-A-59,70), locational studies (I-A-26,29), and theoretical analyses (I-A-32,70) all suggest that highways played a significant role in migration of retail trade to the suburbs.

c) Services.

General service employment, specialized services and government employment have remained strong in the central cities. The gain in service industries in central cities over the last 15 years was numerically not too different from that in the suburbs; in terms of respective percentages it was, of course, much less. Highways do not appear to have played a major role in the relative distribution of service industries (I-A-29). Mass transit appears to be more significant in this respect.

The steady and continuing decline of central cities relative to the suburbs over the last twenty-five years was not caused by the automobile. However, automobiles and highways facilitated the process, determined to some extent its components, and played a large role in determining the geographic distribution of urban activities.

B. Social Impacts

Direct social effects of highways on a community can be assessed in terms of dislocation of households and business within the right of way, taking of public lands, removal of recreational areas, etc. However, there is evidence that there are secondary impacts on the stability of existing communities brought about by changes associated with the highway. Much of the work on "social" impacts involves specification and testing of indices or other indicators of social conditions and change, and deals largely with abstract concepts that are controversial even to social scientists. Recent work in this field deals primarily with definition and measurement of composite indices of secondary social impacts, since it is generally agreed that a single variable cannot be used to quantify the often controversial effects of highways on communities (I-B-11,26,50).

One such composite indicator is the "mobility index" (I-B-50). Changes in the index reflect impacts of highways on community stability and cohesion. Variables used include percent of persons five years or older who occupied the same residences for five or more years; percent of housing units 20 years or older occupied by the same household continuously; percent of single-family residence units; and percent owner-occupied units. These quantities were combined linearly to yield a mobility index.

The index was successfully applied to a test area in Beverly Hills, California (I-B-50). Data problems were encountered elsewhere. Although a simplified index was designed, it is doubtful that the mobility index can be used generally to evaluate community impacts of highway construction.

An empirical method for measuring residential linkages and linkage patterns has been suggested as a basis for estimating community consequences of transportation projects (I-B-11). Linkage definition involved analysis of activity patterns and important destination points for households.

Activity patterns were described by assigning a vector to each destination point. Each vector originated at the homesite and contained elements describing the characteristics of the activity site (e.g., geographic location, type of activity), and characteristics of the household's interaction with the site (e.g., trip rate, mode, travel time). Activity categories included full-time work; school; religious; part-time work; shopping; recreation; informal socializing; restaurants; community activities and formal socializing. Three principal modes of travel were considered: car, public transportation, and walking.

Definition of a set of residential linkages was based on travel surveys to identify a complete set of destination points for each household (travel diaries); household interviews to identify the activity sites considered important; and discriminant iterations analysis to identify the criteria underlying the household's choice of important destination points (linkages).

The analysis was applied successfully in a case study in Skokie, Illinois (I-B-11). However, as the authors admit, the procedures used to define residential linkages represent the value set of the authors, not necessarily those of the households. The small sample size and its intense geographic concentration limit possible inferences on the general applicability of the results. General use of the method is also restricted by the high cost of the necessary surveys (I-B-11).

A simplified mobility index has been formulated based on easily available information (city directories) (I-B-26). Neighborhoods were operationally defined as combinations of city blocks with homogeneous residential housing characteristics. The mobility index for a neighborhood measured residential mobility at five-year intervals simply through the proportion of residents in the same dwelling units, base year compared with five years past.

In case studies of Austin, Houston, and Dallas, Texas, neighborhoods were grouped by socioeconomic level and by their spatial relation to freeways (I-B-26). Study neighborhoods included communities bordering a freeway and communities segmented by a freeway. Neighborhoods with similar social and economic characteristics, but not in close proximity to a freeway, were used as controls.

Statistical analysis showed that the segmented neighborhood category was a significant variable. Residential mobility is likely to increase significantly for a segmented neighborhood. Conversion of single dwelling units to apartments or addition of new multiple dwelling units is also likely to take place in segmented neighborhoods (I-B-26).

Problems arising from perceived conflicts between established community values and forces tending to alter the status quo have been the subject of a number of normative studies dealing with the development of an integrated highway planning process (I-D-1,5,8,11,12).

Property values, housing stock, recreational facilities, and aesthetics were identified as indicators of social and community disruption (I-B-30,50; I-D-8).

C. Land Use and Values

1. Land Use.

a) Residential.

Residential use of land is not related to highways in any simple way. Low density, single-family development is often independent of highways, i.e., other factors (socioeconomic, zoning protection, schools) have predominant influence (I-A-43; C-01,08,11,29; IV-07). However, highways appear to promote conversion of vacant (farm) land to low density residential use at the urban fringe (I-C-08,29,43; IV-07). Generally, such development takes place some distance away since various factors related to highways (induced commercial development, noise and air pollution) inhibit residential uses (I-C-08).

High density residential development appears to be promoted by highways, particularly at or near interchanges. Particularly notable is development of multi-family apartments along circumferential highways (I-A-12).

b) Industrial and Commercial.

Highways promote conversion of vacant and residential land to commercial and industrial uses. Findings of case studies on land use are consistent with general patterns of location of industry and commerce (see section I.A.); in brief, case studies show that increased accessibility provided by highways introduces pressures for commercial development of land (I-A-12,43; C-01,08,11,29,32,43; IV-07).

Arterial streets and radial highways tend to promote string development while circumferential highways tend to promote more comprehensive development and weld suburban communities into a cohesive whole (I-A-12,63). Circumferential highways may lead to accelerated commercial development along major arterials intersecting them (I-C-32).

Highways and other all-weather roads are significant factors in geographic concentration of retail business in rural areas (I-A-65).

Land use changes are most rapid, and land uses most intensive, at or near interchanges (I-A-12; C-29,32). Highway oriented businesses are prominent components of development at rural interchanges (I-A-12, 25,40; C-29,32,50). Industry, commerce, and high-density residential uses appear much more frequently than highway-related businesses in development at interchanges along circumferential highways (I-C-50).

c) Vacant and Rural Land.

The amount of vacant or farm land is often a significant factor in the rate of development of an impacted area. Generally, land utilization progresses from agricultural to a combination of agricultural, residential, commercial and vacant land, with subsequent changes involving some conversion from low intensity uses (low density residential) to commercial or industrial. Highway impacts appear to be most pronounced initially and are most evident in the rates of conversion of farm or vacant land. Later changes depend on the rate of urbanization of the area as a whole and are often independent of the highway (I-C-08).

Land development at rural interchanges involves predominantly highway oriented business -- service stations, motels, restaurants (I-A-40; C-50). Topography and distance to nearest urban area are significant variables in the rate of development (I-A-40). Quadrants on the right-hand side of motorists approaching the interchange on the main (Interstate) highway are more prone to development (I-C-50). Directional and cloverleaf interchanges have roughly equivalent amounts of development. Among cloverleaf interchanges, those with access provided by frontage roads have significantly more intensive development than restricted access interchanges (I-C-50).

2. Land Values.

The value of land adjacent to new or improved highways increases substantially, typically in the range of 100% to 400% over that of control areas in a ten-year period. It should be noted that highways in urban areas are located so as to minimize land costs. Therefore, land values in a highway corridor are likely to be less than metropolitan averages before highway construction.

Changes in land use are important in determining appreciation. Land value increases are most substantial after conversion to a more intensive use; particularly, when farm land is converted to commercial use (I-A-63). The value of land used for single-family dwellings is, on average, not affected significantly by highways (I-C-01).

The value of farm land seems to vary with its location with respect to roads. When other major determinants of farm value are taken into account (particularly, land productivity and type of agricultural use), farm land values are least for locations on dirt roads; and are progressively greater for locations on gravel roads, farm-to-market roads, and state highways (I-C-02).

Appreciation of (urban) land depends on its location with respect to the highway. In some instances, increases were at a maximum for land abutting the highway and declined regularly thereafter (I-A-30; C-01); more complicated relations were found in other cases (I-C-01,32).

II. Mass Transit

Mass transit, bus and rail, affects urban activities through the same mechanism -- accessibility -- as highways. However, the differences between car and transit modes of travel have an important bearing on their secondary effects. Mass transit is an inherently less attractive means of transportation for most people because of fixed routes, a combination of walking and waiting with riding, and the lack of small comforts and privacy. It is often pointed out that mass transportation, where available, is substantially less expensive than auto travel. This is true when automobile ownership is avoided. However, if an automobile is owned, the overhead costs of depreciation, maintenance, interest, and insurance must be paid even if the vehicle is not used. Therefore, transit must be used for all trips to provide significant savings in cost; such a choice involves a substantial sacrifice of personal mobility.

The majority of studies dealing with secondary impacts of mass transit are evaluative and projective rather than retrospective. This is hardly surprising, since comparatively little was invested in new facilities until very recently. Mass transit in the United States declined steadily from its 'abnormal' peak during the years of World War II to the relatively minor position it has in transportation today. Only in the 70's, after the congestion, pollution, and inordinate energy consumption of the automobile became generally apparent, did mass transit generate new interest and new support.

The decline of mass transit over the last twenty-five years was, in a sense, a secondary impact of highways and of expanded mass production of automobiles. While car ownership rose dramatically, mass transit ridership fell from about 17 million passengers in 1950 to only 6.5 million in 1972 (8). The decline of mass transit was equally severe by any other yardstick (8). However, some bright spots in this bleak picture have appeared recently: the BART system in San Francisco, MARTA in Atlanta, METRO in Washington. Plans for new systems or extensions have also been drawn for a number of other urban centers (8).

Mass transit typically serves highly urbanized areas; its setting makes it difficult to isolate secondary impacts of mass transit from the diverse influences shaping urban growth. The absence of hard data, the episodic character of the impact literature, and the limited number of available studies make generalizations about impacts of mass transit tentative at best.

1. Economic Impacts.

a) Manufacturing Employment.

There is no clear evidence that mass transit has a significant impact on manufacturing employment. Increased employment through improved accessibility to jobs has been cited as a benefit of mass transit, usually for inner city minority or disadvantaged groups (II-07,10,22,35,50). Available data are limited, but on the whole, they do not support this claim. For example, special bus routes designed to improve access of inner city residents to suburban manufacturing locations have had little impact on employment (II-07,22).

b) Wholesale Trade.

Mass transit is not directly relevant to wholesaling. There is no evidence that location of wholesale business bears any relation to mass transit facilities.

c) Retail Trade.

Mass transit is generally viewed as having beneficial impact on retail sales. The reference is to retail trade in the CBD and the ability of the CBD to compete with suburban shopping centers. The evidence, sketchy as it is, seems to support this view (II-19,41).

d) Services.

Mass transit has a significant impact on location of services (insurance, real estate, banking, other specialized services). Analysis of changes in land use associated with rapid transit facilities shows considerable development of office space (II-14,19). It may be inferred that services, the most intensive users of office space, tend to locate near areas served by rapid transit.

e) Impacts on Inner Cities.

Mass transit, particularly rapid transit, is generally regarded as a revitalizing force for urban centers. The available evidence is ambiguous. Improved accessibility within the city is clearly a benefit to the urban core; improved accessibility between the inner city and outlying (suburban) locations may accelerate rather than reverse the decentralization trend (II-14). High speed transit apparently helped the downtown area in San Francisco (II-20,41). In Philadelphia, the Lindenwold Speedline appears to have accelerated development of suburban office space at the expense of downtown areas (Philadelphia and Camden City) (II-14).

2. Land Use and Values.

a) Land Use.

The relatively limited available evidence suggests that rapid transit stimulates intensive land uses: high-rise apartments, office buildings, urban retail centers. Primary evidence of impacts on land use is provided in studies of Toronto (II-19), Philadelphia (II-14), and San Francisco (II-41).

b) Land and Property Values.

Some of the earliest impact studies of rapid transit deal with real estate values. For example, a study of the Flatbush Avenue Line in Brooklyn, New York conducted in the early thirties combined before and after with study/control area comparisons to derive quantitative impacts (9). It was found that assessed valuations per square foot increased near rapid transit stations by factors up to 10 or 12 from 1920 to 1930. Impacts on real estate values were confined within about 1,000 feet of the station (9). Similar results were obtained in a study of the Cleveland Rapid Transit System (10). Other studies also suggest substantial increases of real estate values following extension or introduction of rapid transit (II-14,19,41).

Two recent impact studies illustrate effects of rapid transit on land use and values. The 4.5 mile Yonge Street Subway in Toronto was opened in 1954. In 1963, an eight mile crosstown extension was completed; additional extensions are planned to enlarge the system to a total of 21 miles. An analysis of real estate changes in Toronto partially suggests that the subway was responsible for two-thirds of the property value appreciation over the period 1952-1962 (II-19). Tax assessment increases in districts contiguous to the subway ranged from 45% to 107%, while the remaining city areas averaged only a 25% increase.

About half of all high-rise apartment development in Toronto occurred in four planning districts through which the subway passes. Also, the bulk of major office construction during the same period occurred in three planning districts serviced by the transit line. About two-thirds of all real estate development was within five minutes walking distance from the subway.

The Philadelphia-Lindenwold Speedline, a highly automated, dual rail rapid transit facility was opened in 1969. It links the Philadelphia CBD with the City of Lindenwold in Camden County, and passes through several low-density suburban communities in southern New Jersey. The Speedline appears to have increased the rate of office space development in Speedline communities. Associated with this increase was a displacement of activities from Philadelphia and Camden City. Thus, the facility appears to have accelerated the decentralization trend rather than reversed it (II-14).

III. Wastewater Facilities

The influence of public wastewater facilities -- primarily treatment plants and trunk sewers -- on urban activities and land use patterns has received limited attention. An extensive search of recent literature identified only a few, largely qualitative, empirical studies. Accordingly, the discussion of secondary effects of wastewater treatment facilities given here is largely based on causal relationships between wastewater service and location decisions. This analysis is consistent with the limited findings or hypotheses available, and has been supported in a preliminary series of empirical case studies (11). It suggests that under a set of limiting conditions not uncommon in metro-politan areas today, sewer investments can be a principal determinant for the location of development.

A. Business Location in Relation to Sewers *

The influence of public wastewater investments on the location decisions of businesses depends largely on the extent to which industry groups rely on sewer systems for the disposal of wastewater. Since the 1972 Water Pollution Control Act Amendments are almost certain to change this reliance for many industry groups, it is not possible to identify classes of businesses that have similar sensitivity to sewer service. In this discussion we assume that all businesses have some requirement for sewer service, whether sanitary sewage from offices or water wastes from production processes. Business activities are divided into two classes: Industry, comprising manufacturing, wholesale trade, and other firms with large labor or material needs; and commerce, including those firms which primarily sell goods or services to households.

1. Industry.

Industrial location (see Ch. II) depends primarily on access to labor and to external markets. So important are these factors that the relative influence of public sewer service is usually small. The absence of sewer service in a particular location may nevertheless effectively constrain development. While most industries are not sensitive to marginal differences in land costs, the need to fund their own private wastewater system may prove prohibitive in terms of additional expense. An industrial firm, for example, may find it less expensive to purchase developed land with adequate sewer service, demolish existing structures, and build its own plant than to locate where undeveloped land is cheap but no sewer service is available. And since areas with existing sewer service usually have higher accessi-bility, they are intrinsically more attractive than undeveloped, un-sewered land in an inaccessible location. Only large-scale industrial development, e.g., a single major plant or an industrial park, provides economies of scale sufficient to make private wastewater facilities

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* Not supported by references

cost effective. Even in this instance, a potential site is more attractive if public sewer service is available.

Construction of urban highways magnifies the importance of new sewer investments by making suburban sites attractive for industrial developers. Such sites combine lower land prices than central locations with equivalent access to labor and improved access to external markets. Under this combination of conditions, a new sewer investment in the area will stimulate industrial development. The absence of sewer service, on the other hand, may limit such development to a relatively minor amount. Stated differently, if two locations within a metropolitan area have similar land availability, price, and access levels, but one has public sewer service while the other does not, then the location with sewer service will be favored for industrial development.

In practice, industries or industrial developers often do not face this choice. Local planners typically have been eager to extend sewer service to industrial developments because of the stimulus they give to the area's economy. Often, the industry or developer pays only a nominal fee for this service, with the balance of costs amounting to a subsidy paid by local residents. In this case it is more appropriate to say that industrial development caused the sewer investment rather than vice versa. But it is likely that failure to provide sewer service would have prevented development from occurring.

2. Commerce.

The effects of sewer investments on commerce are quite similar to those on industry. The principal relationship is a negative one, in that the absence of public sewer service constrains commercial development. Commercial location is sensitive to population distribution and access to households; accordingly, the relative influence of sewer service is probably small. Commercial firms, like industries, are willing to pay any necessary premiums on rents or land prices in return for high access.

Conditions under which a new sewer investment will have important secondary effects are: availability of vacant, previously unsewered land available at low cost, relative to average cost for comparable commercial sites, and having high access to households. Individual stores or small office structures of low density may not require sewer service. Therefore, some low density commercial development is possible without public sewers.

The secondary effects of sewers on residential development affect, in turn, the location of commerce. New residential subdivisions of any size are followed by supermarkets, drugstores, and the like. The regional pattern of residential development -- coupled with transportation facilities -- determines the optimum location of shopping centers and office buildings. Thus, at least theoretically, sewers have a lagged effect on commerce through residential location that may be more profound than more immediate impacts.

Interactions between major commercial developers and local sewer planners are generally extensive. In particular, developers of regional shopping or commercial centers -- which often include dozens of retail outlets as well as office space -- are often influential in the local planning processes. Even though land may be unsewered when purchased by the developer -- and available, therefore, at a lower price -- there are often informal agreements with local officials that sewer service will be provided. The developer probably recognizes in such instance that if his agreement falls through, wastewater disposal expenses will reduce, but not eliminate, his profits. While no data have been gathered to check this hypothesis, such developments are probably large enough to allow funding of private wastewater systems in the absence of public service.

For both commercial and industrial development, one condition necessary for significant secondary effects is lower land price than average. The provision of public sewer service usually causes a rapid increase in land prices, typically by a factor of two to four. However, because developers often buy their parcels after sewers are planned but before they are constructed, they collect the benefits of any subsequent price increase. Advance information and slow price responses to altered conditions make this form of speculative activity possible.

B. Residential Location in Relation to Sewers *

The principal link between housing location and sewer service is density of residential development. Because developers typically increase their profits (and offer reduced housing prices) through more intensive use of land, the availability of sewer service is a stimulus to build. This is particularly true in major metropolitan areas, where generally inflated land prices discourage low densities even in outlying locations. In many regions, use of septic tanks in new homes has virtually ceased because of the large lot sizes required for leaching fields. The importance of sewer service, therefore, appears to be growing.

1. Residential Growth in Relation to Sewer Investments.

In an empirical examination of rapid development in an urban fringe area of about 17,000 acres located in the northeast section of the City of Philadelphia (III-06), time series data were used to relate land values and land development to accessibility, availability of public facilities (including sewers), zoning, and ownership characteristics. The study period extended from 1945, when post-war development pressures were beginning, to 1962.

Parcels of land with access to trunk sewers averaged four times

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* Not supported by references

the value of land not accessible to sewers. Because the data were aggregated over an 18-year study period, part of this difference can be ascribed to higher average prices paid in later years when land without sewerage was not available in the area. However, part of the difference no doubt resulted from different prices at the time of transaction. Interpretation of these results is ambiguous, since two different mechanisms may have produced such a correlation. Sewers might have directly led to increased market values or development pressures could have led local authorities to sewer the most valuable and attractive areas. It is probable that both mechanisms operated during the study period.

Time series data also indicated that average annual percentage increase in price of land not accessible to sewers was about double that of sewered land. In explaining this result, it is noted that unsewered land was transacted in meaningful amounts only during the first half of the study period (III-06). Subsequently, all land in the area was fully sewered. It appears that as sewers were extended, the influence of other factors became predominant.

The main conclusion of the study was that lack of sewers acts as a negative constraint on development. Their absence inhibits functioning of operative builders, although it clearly does not prevent all development. The existence of sewers, on the other hand, cannot overcome other forces limiting development in subareas. The study concluded that whether selective installation would channel construction from one subarea to another was an open question.

A retrospective study of development in Fairfax County, Virginia contains a largely qualitative description of the influence of sewer investments on residential development (III-10). Although lacking in rigorous empirical support, the study provides a scenario of rich details of impacts and their causes, and makes a strong case for a major role of sewers in sprawl development.

Fairfax County, a southern component of Metropolitan Washington, experienced nearly a five-fold increase in population from 1950 to 1970. The immigrants were largely accommodated in single-family houses in the $30,000 to $40,000 range. Because of the demand for low-density development, the hilly watersheds of the area, and the large reserves of undeveloped land in the county, sprawl was dominant in the tidal wave of development. County officials, the study claims, exacerbated this phenomenon by dutifully extending interceptor sewers into totally undeveloped areas and granting zoning variances willingly. As a result, large amounts of open space were needlessly taken, tax burdens on existing residents grew, public services stagnated, and land speculation increased.

To put these events in perspective, it is important to acknowledge some purely local factors that encouraged this pattern of development.

The county is under tremendous suburban growth pressure from Washington, D.C. Soils are unsuitable for septic tanks; accordingly, sewerage is almost a necessity for development. The county financed sewers largely without federal assistance and consequently increased its indebtedness. Finally, land use plans and controls in Fairfax County were rendered ineffective partially because of court decisions indicating that limitations on development were arbitrary and capricious.

Relations between sewers and population growth in the Washington area were statistically examined in the period 1960 to 1968 in another study conducted by the Metropolitan Council of Governments (III-04).

The EMPIRIC model was the basic framework for the analysis; EMPIRIC calibration data were a major part of the data base. In the EMPIRIC model, the Washington Metropolitan Area is divided into 'policy analysis districts' on the basis of transportation corridors. Changes in households and employment levels (divided into various categories) are allocated in 8-year intervals beginning in 1960. The model was calibrated for 117 districts (defined on the basis of 1960 census tracts) with data for 1960 and 1968.

The Washington Metropolitan Area was further subdivided in the cited study by a grid consisting of 2,000 foot squares. A computer program digitized and identified each grid square by the EMPIRIC calibration district to which it belonged. The impact of trunk sewers on development was analyzed in the first instance by considering development and trunk service for each grid square.

Sewer data were collected for each grid square and aggregated by watershed. Statistical analysis showed that growth in a watershed, expressed as change in share of regional population, was related to change in design capacity of trunk sewers. Changes in share of regional population in a watershed were also related to the amount of vacant land in the area multiplied by the inverse of its average straight line distance to trunk sewers. A good correlation was observed when these three variables were combined into a "composite capacity and location factor."

When the same data were aggregated by EMPIRIC policy district rather than by watershed, no significant correlation of population growth to the "composite capacity and location factor" was found. A relatively poor correlation of growth with changes in sewer capacity was observed; correlation with the amount of vacant land and its average distance from sewer service was also relatively poor. In general, analyses by watershed and by EMPIRIC district did not yield consistent results.

A few other studies provide insights into the nature and causes of secondary impacts of sewers. The most commonly recognized area of secondary impact is new development, including rates, magnitudes, and densities (III-01,06,10). Most studies have focused on residential development in urban fringe and outlying areas where the pressure for development is often highest. Such urban expansion, whether stimulated or simply allowed by sewerage, usually brings with it a set of induced impacts on local governmental services, public indebtedness, and housing characteristics (III-01,10).

Opponents of urban expansion are coming to view interceptors as a primary growth stimulus. The limited empirical analysis available suggest that sewerage systems cannot always be isolated as instrumental causes of development (III-06). However, under a set of limiting conditions not uncommon today, they may serve as a principal stimulus for localized development.

2. Single-Family Housing.

Single-family housing, the least intense of all urban land uses, is not totally constrained by lack of sewer service. Densities for detached homes range, on the average, from one to five units per acre. Depending on soil conditions and topography, septic tank systems can effectively serve up to four units per acre. Conditions are seldom optimal, however, so that in practice septic tank systems often can work effectively only on half-acre or full-acre parcels. And where the water table is high or soils are impermeable -- not unusual conditions -- septic tanks are impractical. Thus even single-family housing construction can be strongly influenced by sewer service.

Since it is not generally economically feasible to construct single family homes by demolishing existing structures and redeveloping the land, the impact of new sewers is directly related to the amount of vacant land in their service areas. Where little or no vacant land exists, as in the case of relief sewers to fully developed areas, single-family construction will not be affected. However, relief sewers to suburban areas often traverse undeveloped locations. While in this instance there may be no significant effects on single-family construction in the intended service area, vacant sites along the sewer line would be likely to undergo development. Similarly, when local wastewater systems in a metropolitan area are integrated into a regional system through construction of interceptor sewers linking local areas, undeveloped sites along the interceptors become attractive for single-family housing construction. Since regional wastewater systems are encouraged by the Water Pollution Control Act Amendments (12), this situation is becoming more common.

Statistical analyses confirm that the amount of single-family housing construction in an area is positively correlated with the amount of vacant, sewered land available (11). By inference, the sewer investments most likely to stimulate construction are those in suburban locations with substantial tracts of undeveloped land. However, where vacant, sewered land is already available in some quantity, new sewer investments will have only a marginal influence on development.

The same analyses, however, show that single-family construction is more strongly correlated with newly sewered land than with vacant land sewered previously. In fact, there is some evidence (11) that the delay or lag between sewer construction and single-family development is minimal or even nonexistent. This suggests, first, a rush to build in newly sewered areas before prices adjust to higher levels normally associated with sewered land. But it also implies that developers have advance information concerning the location of new sewers. In fact, residential developers often request that sewers be extended to subdivisions they are planning. Where this situation presents problems, developers may construct their own sewer system on the agreement that the local government or sewer authority will subsequently purchase and operate the system. Here again the situation is too ambiguous to ascribe a one-way causal relationship between the sewer and the subdivision. However, only the largest subdivisions (e.g., several hundred dwelling units or more) can economically finance their own wastewater system without assistance from local authorities.

Generally, significant increases in single-family housing construction can be expected to follow new sewer investments in areas where there is little vacant, sewered land, where vacant land prices are low relative to the regional average, and where large tracts of contiguous undeveloped land exist. Any variation from these conditions reduces the likelihood of major secondary impacts on single-family housing.

3. Multi-Family Housing.

Multi-family housing, as an inherently intensive land use, requires sewer service. At the same time, apartment and condominium developers do not usually require large tracts of vacant land, and they can pay premium prices for land. Multi-family housing construction, therefore, responds differently to sewer investments than single-family development.

The principal difference, of course, is the necessity of high accessibility for multi-family development, whereas new single-family housing requires much lower access to be successful. Like industrial and commercial development, multi-family residential construction can take place only where both high accessibility and sewer service are available. However, since apartments and condominia can be built in a variety of densities, from two-unit structures to high rise complexes, developers can trade off access for lower densities to some extent. There is, therefore, not a single combination of conditions under which sewer investments significantly affect multi-family construction, but rather are several situations which create a potential for such secondary effects.

The most significant impact on multi-family development will occur when sewer service is provided to areas with high access to existing employment centers and with substantial amounts of vacant land. This situation seldom occurs except in conjunction with highway investments, where previously inaccessible, partially undeveloped areas are made accessible. The combination of high accessibility and land availability is ideal for major, intensive residential development.

If, on the other hand, the amount of vacant land served by a new sewer is small, the amount of multi-family residential development likely is less, but what construction does occur will be intense, e.g., high rise apartments. This difference is largely a matter of land prices, with more units per acre necessary to reduce per unit costs. A relief sewer to a subdivision composed primarily of single-family homes with septic tanks might create such a situation. The amount and intensity of subsequent multi-family construction, however, would depend on the accessibility of the subdivision.

If sewer service is expanded in an area where little vacant land is available and accessibility is somewhat lower, then some apartments or condominia will probably be developed, since the scarcity of land may raise prices enough to prohibit new single-family homes. In this case, however, the lower level of access would probably limit density.

Since sewer investments usually serve areas with several combinations of these characteristics, a range of effects on residential development are likely. Portions of the service area with isolated parcels of vacant land and good access will be attractive for apartments; more outlying portions with contiguous tracts of vacant land may be subdivided for single-family homes. Local land use controls, such as zoning, may moderate these secondary effects.

C. General Land Use Effects

General land use secondary effects of sewer investments identified by the literature are summarized below.

- The increased attractiveness of sewered areas encourages land speculation and increased real estate values (III-06). Although it is difficult to isolate sewer-related increases, a doubling in value seems common, while three-, four-, and five-fold increases in value are not exceptional (14).

- Sewer-inspired development is often of the dispersed sprawl type with deleterious effects on available level of public services to residents of the newly developed areas, on per capita public services in the region as a whole, and/or on tax burdens to residents of other areas in the region (III-10).

- A potential physical effect of sewerage investments is decreased water quality through storm water runoff in newly developed areas (14).

Specific mechanisms which provide strong encouragement for development of newly sewered areas include:

- Interceptor sewers servicing undeveloped or partially developed land areas subsidize developers by providing relatively low cost sewer treatment (III-10). The subsidy encourages moderately-priced housing, as opposed to higher priced housing in unsewered areas (15).

- New sewers increase the density of possible development and thus the potential economic "rent" (and development profit) per unit of land to the owner or developer (III-09).

- New sewerage is often partially financed by revenue bonds to be repaid through tap-in and service charges. Local authorities tend to encourage tap-ins through easy rezoning in order to stimulate revenues while the market is strong (III-10). This provides another stimulus for development at high densities.

Two other external factors help cause sewer impacts. The availability of federal funds for capital costs makes over-capacity sewers and regional sewerage systems more attractive to local decision-makers. In the case of over-capacity, local planners again tend to encourage tap-ins in order to quickly repay their share of capital costs. And because regional systems with a central waste treatment plant often require long interceptor lines through undeveloped areas, they encourage development of open space (III-03).

An important qualification is that lack of public sewer investments does not necessarily stop further development. If developmental pressures are intense, private sewerage systems are financially feasible, not only in the form of individual septic tanks, but also as package treatment plants. Thus development can continue unchecked without public investment in sewer facilities. But the form, intensity, and rate of development may be significantly altered.

IV. Modeling Techniques

Attempts to quantify probable secondary impacts of infrastructure investments include projective techniques based on single equations (generally calibrated empirically), partial models dealing with a narrow range of specific impacts, and comprehensive models dealing with major aspects of a regional system (16, IV-31,36,37).

1. Projective Equations.

Single equation "models" have been used to describe or forecast aspects of development (generally land use) given a set of independent variables. The set generally includes variables related to availability of sewers and transportation.

Kaiser (IV-29) analyzed the decision-making process by various types of developers of residential (single family) subdivisions. The analysis combined a causal specification of independent variables with empirical study of their importance to arrive at a simplified expression for predicting the probability of subdivision development. The model consists of a linear combination of only four predictor variables (socio-economic rank, distance to nearest elementary school, accessibility to employment, and availability of public utilities and services).

Regression analyses using data on two medium-sized cities showed that socio-economic rank was the single most important variable determining subdivision development. Level of zoning protection, distance to nearest major street, and public utilities were next in order of importance. Physical characteristics of the land were not important.

The model treats the spatial distribution (but not the amount) of only one sector of the residential housing market (single family subdivisions). It cannot be used for forecasts over long periods of time. Furthermore, since contextual factors were found to be important, the model must be calibrated separately for each urban area.

A similar approach was used by Kaiser and co-workers (IV-30) in a study of land use conversion. Regression analysis was used to determine whether landowners on the urban fringe would sell their property for development. Six predictor variables were identified and grouped into two categories, landowner and property characteristics. Important landowner characteristics were: residence on or off the land; employed or retired; single or joint ownership; and length of ownership of the property. Property characteristics were: amount of contiguous development and assessed value (per acre) of the land. Experience with the model showed it to be more accurate when calibrated for each of a series of concentric rings around an urban center.

Another approach to single equation models is exemplified by Schlager's work (IV-43) with linear programming in devising minimum cost, land use plans. An objective function specifying costs of development for different land uses is minimized subject to a series of constraints (land requirements for forecasted urban activities) and design requirements (e.g., exclusion of construction on flood plains, restrictions on adjacent industrial and residential development, etc.). Required inputs in the analysis are costs, inventories and forecasts of land development, and design requirements.

The use of linear programming assumes that objectives can be represented in common terms, e.g., dollar costs. It also assumes that a stable optimum can be attained in the time period under study; this implies, in turn, that objective and constraint functions and their coefficients are invariant.

Similar assumptions are necessary in regression analysis. Calibration of the weight of independent factors generally implies that these factors are invariant over the study period. A corollary assumption is that "independent" factors are not significantly affected during the projection period by the variables being predicted (i.e., by the dependent variables in the model).

2. Partial Models.

a) Land Use.

Early economic theories of land use generally postulated a free land market in which different types and numbers of land consumers compete for different parcels of land. Land owners rent (or sell) to the highest bidder. The bid of each consumer or group of consumers depends upon their needs and their income. Consumers minimize the sum of expenditures for ground rent and transportation consistent with their requirements and preferences (17). However, because each parcel of land goes to the highest bidder, low income families must join in bidding for small parcels of land, thus increasing density. Furthermore, density tolerance varies with household composition. "Thus a certain natural selectivity takes place in which both income and density tolerance are at work" (17).

Industrial and commercial consumers operate in the same fashion, but their requirements are different. Rather than employment and amenities, which guide residential choice, industrial necessities include labor, markets, materials and services. These factors are weighed differently by different types of businesses, and each industry has its own density tolerance.

In spite of their simplicity, these early economic theories of land markets and use introduced several important concepts that strongly influenced later approaches to the problem. Most important were the role of accessibility in determining land use and the principle of minimization of land rent-transportation costs (or its equivalent, maximization of disposable income).

Among recent land use models, the University of North Carolina Model (IV-07) treats conversion of open land to residential use. In the UNC model, an entire metropolitan area is divided into cells. Some cells are exogenously specified to be unavailable for residential development based on a forecast of non-residential land uses. The probability of development of the remaining cells is proportional to their "attractiveness" to population groups. Attractiveness is a weighted combination (calibrated by regression) of initial assessed value, accessibility to work areas, availability of public sewerage, and accessibility to the nearest major street and nearest elementary school. In each forecast interval, units of development are assigned to cells probabilistically according to attractiveness scores. This assignment continues until all forecasted demand is met.

The UNC model is applicable to areas of growth and new development. Housing supply is assumed to be totally governed by demand. Neither interaction of supply and demand, nor its result, housing prices, are considered within the model.

Neglect of supply-demand interactions is a characteristic of many land use models. Supply of land for specific uses is often formulated as dependent upon demand. For this reason, research has centered on techniques to derive supply from demand. Two techniques used extensively are regression analysis and optimization via linear programming.

b) Economic Activity Location.

Intraregional economic location models address, at least implicitly, relative advantages of regional sub-areas. Such advantages can usually be translated in the end in terms of either lower costs of doing business or in larger and more attractive markets. These two categories provide a convenient means for disaggregating industries in economic location models. The primary determinant of location of market-oriented industries is, almost by definition, market attractiveness. On the other hand, location of non-market oriented industries is influenced by a variety of factors which make up the overall cost of doing business.

A so-called "gravity formulation" was the basis of the retail market potential model developed for Baltimore by Lakshmanan and Hansen (IV-32). The gravity model asserts that the extent of interaction between two areas is proportional to the mass (or size) of the two entities, and inversely proportional to a power of the distance between them. Measures of mass may be income, car registrations, school enrollment, etc., depending upon the topics addressed by the model. For example, the gravity model has been used in transportation studies to generate traffic volumes between a number of points by using population as the indicator of mass and by expressing "distance" in miles, time, or travel costs.

The actual model developed by Lakshmanan and Hansen for Baltimore was a variant of the gravity formulation generally known as the intervening-opportunities model. This version assumes that distance *per se* is not a determinant of interaction but rather, as *Stouffer* (18) suggests, "the number of persons going a given distance is directly proportional to the opportunities at that distance and inversely proportional to the number of intervening opportunities."

The *Lowry* model (IV-35) incorporates economies of scale by imposing a minimum facility size constraint on the location of retail activity. It is a static model that iteratively solves for equilibrium between employment and residential location. Lowry models not only the home-to-shop trips, but the work-to-shop trips as well, so that retail location is dependent upon all employment and residential location. This is done by assigning to each zone a score reflecting accessibility to consumers (from home and work). Total retail employment (generated by a conversion factor from total households) is distributed among zones in proportion to the accessibility scores.

The *EMPIRIC* model (IV-50) employs, as do a number of other models (19,20,IV-51), regression analysis to calibrate the extent to which various independent factors determine employment location. These factors are exogenously specified to provide the bases for future allocation of employment. In EMPIRIC, different combinations of the following "locator variables" are used for projection and allocation: intensities of land use; zoning practices; automobile accessibilities; transit accessibilities; quality of water service, and quality of sewer service. Changes in the following variables were allocated to different zones in a study of the Boston area: white- and blue-collar population; retail and wholesale employment; manufacturing employment; and all other employment.

c) *Residential Location*.

As with economic activity, accessibility figures prominently in many formulations of residential location. In fact, it is convenient to group residential location models according to whether accessibility is the prime determinant or merely one of a broader set of locational criteria. Models in the former group include the original Kain formulation, Alonso's work, and Lowry's metropolitan model. The latter group includes De Leeuw's housing model, the NBER urban simulation, the San Francisco model, and Ellickson's formulation.

All these models, whether accessibility-dependent or not, include, generally explicitly, utility functions representing locational criteria of households and the households' attempts to satisfy these criteria, that is, maximize the utility functions through locational decisions.

Kain (IV-27) postulated that households minimize overall costs consisting of transportation expenses and location rents. Location rents per unit of residential space of a stated quality and amenity are assumed to decrease monotonically with distance from workplaces. At any given distance from an employment center, the total location rent increases with consumed space.

Kain considers transportation costs to have three components, each of which includes both dollar and time costs. However, only the cost of the journey between residence and workplace is included in the model. The cost of obtaining services in the residential area was omitted because it was assumed to be the same for all areas. Costs which vary with the residence's distance to other areas were assumed to be trivial.

In an application of the model to the City of Detroit, inputs were the location rent function, travel costs, and household groups' incomes and preferences for residential space. In Detroit, households were allocated to one of six concentric rings through a cost-minimization procedure in a linear programming format. The minimum-cost location (residence ring) of any given type of household is defined by its preference for housing space and by distance from the employment center at which the sum of the (increasing) transportation costs and the (decreasing) total location rent for the preferred type is at a minimum.

Lowry's model of a metropolis (IV-35) is another static equilibrium formulation in which the journey to work is the prime determinant of residential location. Households are allocated iteratively to zones in the area in proportion to each zone's score, which is based on the zone's accessibility to employment. The first distribution of households determines an approximation to the retail employment distribution. This approximation, together with base employment locations, redefines the household distribution. The new household distribution is used to revise the retail distribution, and the sequence continues, converging to an equilibrium. Lowry's model is based on the same assumptions as Kain's formulation.

De Leeuw's housing model (IV-10) provides the first example of a conceptual extension of accessibility-oriented residential location models. This equilibrium model provides a one-step projection of the distribution of families and single persons among concentric zones of a hypothetical metropolitan area. Three behavioral entities are included in the model: households, landlords, and builders.

Households attempt to maximize (in a linear programming format) a utility function which consists of the following elements: housing services (measured in dollars) provided by the dwelling unit; the income remaining after renting a unit (i.e., after purchasing services); time available after traveling; and zonal average income.

Landlords attempt to maximize profits by adjusting the services provided and housing prices. Builders meet any demand at a price equal to the exogenously specified capital and operating costs.

An iterative sequence is followed in which households choose dwelling units according to their utility-maximizing criteria. A few dozen households and units represent the entire market. Some units are selected by more than one household, and some not at all. In these situations, the housing price is raised or lowered, respectively, by an exogenously specified amount, and the amount of services provided modified accordingly. Minimum limits are set for the rent levels. The next iteration of household location is performed with the new distribution of prices and services available to households. This process continues as long as housing units either are selected by more than one household or are vacant with a price above the minimum allowable level.

De Leeuw assumes that, contrary to Kain's journey-to-work theory, housing quality and neighborhood (income) effects are, in fact, determinants of residential location. In addition, a more explicit representation of supply-demand interactions yields price adjustments in working toward a market-clearing solution.

Market-clearing interactions are placed in a more dynamic framework in the NBER model (IV-28). Rather than solve for equilibrium, this formulation documents the effects of housing submarket disequilibria from one time period to another in a time-stepping simulation.

Housing "bundles" replace De Leeuw's concept of housing services. These bundles include attributes of the dwelling unit as well as exogenously specified attributes of the neighborhood, such as density, quality of public services, and socio-economic characteristics.

Each household has a preference for a specific bundle and attempts to minimize (by linear programming) its travel costs according to the location of available supplies of housing. To compute these, interzonal matrices of travel costs and times are specified for different travel modes. The result is that each moving household (not all move in every time period) chooses the housing bundle it desires at the location nearest its workplace.

The total supplies of housing change gradually. Filtering occurs when is it not economic to maintain a unit, given the market price the unit is drawing. Construction of new units also depends on market prices and associated economic factors.

A formulation similar to the NBER model, but without explicit consideration of accessibility, is the *San Francisco Housing Simulation Model* (21). Households with specified desires for housing types are matched with available supply of each type. Excesses of supply or demand in submarkets generate price changes that affect the economic feasibility of changing the level of stock of each housing type.

Households are broken down by size, income, race, and age of head. Housing is disaggregated along two lines: dwelling unit characteristics (cost, size, and condition) and what are essentially "neighborhood" attributes (socio-economic status of residents, density of development, topography, and historic status).

Each household type (114 in all) is assigned a preference list of housing types. To the extent that dwelling unit and neighborhood characteristics do not match the characteristics preferred by the population (all have the potential for relocating in each time period), price and stock (construction and conversion) changes are examined for economic feasibility.

The mechanisms by which market interactions produce subsequent changes are similar to those in the NBER model, but the San Francisco simulation is notable for its assumption that accessibility plays a minor role in determining location, and for its extremely disaggregated representation of supply and demand.

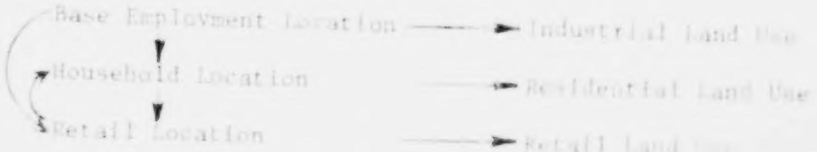
Sociological surveys provide a number of factors for possible inclusion in locational decision functions. Stegman (I-B-37) reports, from a national survey of reasons for household relocation, that the most frequently cited cause was a desire for more space. Other causes, in order of frequency were: desire to own a home; forced moves; desire for a lower-cost alternative; improved housing quality; and improved neighborhood quality. A move to a location more accessible to a job was ranked seventh.

Hinshaw and Allott (I-B-17) report the outcome of a housing and neighborhood preference survey of urban youths, with the results disaggregated according to race/ethnicity, family income level, and type of housing presently occupied. Housing preferences, throughout almost all groups, were for single-family suburban homes, with little desire for proximity to relatives. Neighborhood preferences, ranked according to importance, were "...overall, safety and proximity to good schools are considered to be critically important. Attractiveness, proximity to transit stops, friendliness of neighbors, and access to parks are considered important or very important as decisional factors, while proximity to shops, entertainment, and place of work are considered relatively unimportant."

3. Holistic Models

Holistic models incorporate theories of land use, housing, and residential and employment location to project population, levels of employment, and their geographic distribution.

The Lowry model (IV-35), discussed above in connection with household and industrial location, has provided the basic structure for many subsequent holistic modeling efforts. The iterative solution sequence of the Lowry model can be summarized as follows:



The Pittsburgh Urban Renewal Simulation Model (IV-46) incorporated a revised Lowry formulation named Time Oriented Metropolitan Model or TOMM (IV-09), an input-output interindustry model, and an intraurban industrial location model called INIMP (IV-41).

The input-output model generates basic employment projections for several employment categories for the region, county, and city. INIMP distributes projected base employment increases and decreases among tracts in the city. Employment decreases are either: (a) allocated to tracts in proportion to the amount of industry in that tract; or (b) if the decrease exceeds externally specified "shutdown percentages," a Monte Carlo procedure deletes facilities until the projected decrease is less than shutdown levels, allocating the remaining decrease according to (a). Increases are allocated in a three-stage process. Some industry types require certain location attributes (e.g., near a river or airport), which are specified for the model. Tracts with suitable attributes may accept corresponding industry types. Allocation among these tracts is in proportion to scores assigned to them according to four factors: assessed value, available land, structural density, and industrial clustering. Finally, new facilities are generated by any tract industry increase which exceeds a capacity constraint.

This base industry location provides the inputs for TOMM. The Lowry-type iterative process locates population and retail industry in the city. There are three changes in this formulation from that of Lowry's. First, it is assumed that reduction of the study's boundaries to that of a city does not conflict with the location model's structure, i.e., exurban or inter-county commuting is insignificant. Second, households are disaggregated by income. Income and households determine, through a conversion factor, retail activity distribution. Third, only a fraction of households and retail activity can relocate within one time period, thereby abandoning the equilibrium solution for a dynamic simulation.

The *Bay Area Simulation Study* or BASS (IV-06) modeled a much larger area -- that of nine and thirteen counties, in two different versions of the model. Historical employment and population trends were extrapolated to obtain totals for the area, with the assumption that the forces behind this development in the past would continue in effect in the future.

Different types of employment are located according to a variety of formulations. Primary (agriculture, mining, etc.) employment is allocated by trend extrapolation. Construction employment is allocated in proportion to new housing and new employment. Retail employment is allocated in proportion to relative attractiveness indices, which combine market potentials (generated by a gravity model) with a measure of commercial site suitability. This suitability was calculated using regression analysis based upon employment in certain other industries, employment and population accessibilities (from matrices of inter-zonal travel times), and density of development.

The allocation of manufacturing industries (IV-17) uses a formulation similar to INIMP. For projected increases, a two-step process is employed. Tracts are first examined for "essential factors" for each industry. Attractiveness scores are assigned to tracts possessing such factors according to regression-calibrated weightings of forty characteristics. These include levels of employment, accessibilities, and land availability. The area with the highest score receives an employment increase equal to the average size of that industry's facility. This process continues until the entire regional increase has been allocated. Industrial declines are allocated among tracts according to the percentage of the industry in each tract.

Household location is computed in terms of housing demand, disaggregated by single- and multi-family housing of high, medium, and low value. Households are allocated to subareas in proportion to each subarea's accessibility to employment. Housing demolition is forecast exogenously. Constant proportions are specified for the value classes of housing, and construction and filtering are formulated to attempt to maintain these proportions.

The entire Northeast Corridor of the U.S. was the subject of the *Northeast Corridor Transportation Project* (IV-08). This analysis was originally designed to include a hierarchy of three models: ECON, an econometric model for projecting industrial sectors' labor demands and the demands for sectoral output; IRIO, an interregional input-output model; and INTRA-1, an intraregional allocation model. IRIO has since been deleted. The INTRA-1 formulation (22) has been changed substantially, and the current version is known as INTRA-II (23). The latter formulation is examined here, and referred to simply as "INTRA."

INTRA was developed as a set of highly interrelated components. Extensive feedback processes in the model produce a time-stepping simulation of the system. INTRA uses the output of ECON to produce forecasts, by county, of employment in industrial sectors, population, income levels, and land use. Incremental changes are computed by econometrically derived equations in order to provide a dynamic formulation.

Changes in employment distribution are based upon counties' relative advantages in procurement, processing, and distribution. Procurement advantage is highly dependent upon accessibility to required inputs. Processing advantage reflects the relative costs of production factors, particularly land and labor. Distributional advantage is dependent upon accessibility to markets and the market potential (for an intermediate good or a final consumable).

Births, deaths, and migration determine county population levels. Births and deaths are formulated as being dependent upon income levels and population densities. Migration is generated by feedback from unemployment, accessibility to employment, and wage differentials. Wage and property incomes are the primary components (though others are also computed) of personal income. Land value is dependent upon the density of the land's use (by population and industry). Furthermore, land consumption by all users is dependent upon the cost of that land.

A similar system of models was proposed by Engle et al. (IV-12). Modifications included a more disaggregated population (by age, race, and skill level), inclusion of the effect of local taxes on locational decisions, and consideration of structural semi-permanence of housing on the housing market and on land use.

Forrester's *Urban Dynamics* (IV-14) effort modeled a complex feedback system intended to represent major forces causing development or decline within a city. The primary variables in the model are three skill levels of population, land, three stages of industry, taxes, and three qualities of housing. The model assumes that all workers live within the city.

Attractiveness of location in the city by population groups is dependent upon unemployment, housing quality, availability, public expenditures per capita, and density of development. As there is no geographic disaggregation, accessibility and its effects are not treated. A specified "normal" growth rate of industry is modified by land availability, labor force, taxes, and past growth. This assumes that all industry types respond to the same locational factors.

Hester (IV-22) has revised the Urban Dynamics formulation to include city-suburbs interaction in the labor market.

The regional dynamics of the *Susquehanna River Basin* were modeled by Hamilton, *et al.* (IV-20,21). The basin was divided into nine contiguous regions relatively independent of each other, except for river water (quantity and quality) interdependencies. For each region, a formulation was provided for interdependencies among employment and demographic variables.

Population was disaggregated into age groups, each of which displays relatively homogeneous behavior with respect to migration, birth and death rates, and labor force participation. Statistically validated relationships were established between unemployment and birth rates and between unemployment and migration by age groups. Unemployment was also a determinant, over time, of labor force participation (the "discouraged worker" effect). A cumulative measure of skills (affecting labor productivity) was maintained for each region.

Employment was disaggregated into export industries and local serving (market-oriented) industries. The latter group was broken down into household- and business-serving components. Export employment was further divided into four component categories, depending upon economic sensitivity of 3-digit SIC industries to labor costs, transportation costs of products to market, and transportation costs of raw materials to processors.

Household-serving employment was calibrated to depend solely on population. Business-serving employment was determined by the level of all other employment. Regional costs in terms of the three export industry factors cited above, and the importance of these factors to each industry, determine the attractiveness of the region to each export industry. Transportation costs were represented as the measured ratio between regional and national transportation costs in an industry. Labor costs (wages) are dependent upon the mix of industries in the region and unemployment.

Swanson and Waldmann (IV-47) later adapted the same basic formulation of economic and demographic sectors for application to Kent County, Michigan. Population was further disaggregated into five occupation groups. The "water sector" of the Susquehanna model has since been revised -- as RIVERZ -- in an application to the Grand River Basin (IV-03).

4. General Discussion.

Partial models have a number of weaknesses. External forecasts of key variables (such as employment or population) often required as inputs are actually highly dependent upon factors endogenous to the models. Similarly, so-called "independent factors," for example, accessibilities and availabilities, are often greatly affected by the variables being projected. There is, additionally, no allowance for shifts in the relative importance of independent factors over time.

Many formulations are of a static equilibrium nature. Therefore, there is no treatment or documentation of the dynamic process by which equilibrium is reached, such as time-lagged interactions of supply and demand in land, housing, and labor markets. It is, in fact, questionable whether equilibrium can be attained by a complex socio-economic system.

Perfect knowledge of and immediate response to regional conditions (e.g., land or housing markets) is assumed in many models. This is a direct consequence of using non-dynamic approaches. In addition, market operation is often assumed to be free of any government influences or constraints such as zoning regulations.

Finally, the wide range of locational decision criteria postulated indicates substantial differences of opinion on the causal forces at work. Particularly notable is the debate over the prominence of accessibility in determining household location. It is clear that significant additional research is needed on the nature of the location process.

Some of these shortcomings are carried over into holistic models. In particular, the use of exogenous forecasts of major variables is widespread. In determining regional levels of population and employment, the questionable assumption of constant forces continuing to shape the future underlies most formulations.

Models treating urban centers in isolation have a serious weakness. These formulations ignore important interactions with outlying areas and their subsequent locational implications.

The location of discrete industrial facilities is currently treated in an awkward fashion. Common units are "average facility sizes" and "shutdown percentages" and much of the mathematics has only a tenuous relationship to real-world phenomena.

Finally, while many models address immediate effects of changes in transportation facilities, there is a notable lack of treatment of the longer-term ways in which regional socio-economic changes feed back to affect the transportation system (e.g., the phenomenon of supply-induced demand).

References

Each publication has been assigned a reference number, used consistently throughout the report. The reference number includes a Roman numeral, indicating a major classification in one of four categories, followed in the case of Highways by a letter indicating a major impact area.

I. Highways

   A. Economic
   B. Social and Demographic
   C. Land Use and Land Value
   D. Political/Legal

II. Mass Transit

III. Wastewater Facilities

IV. Models

An Arabic number gives the order of the publication within each listing. Thus, reference number I-B-23 refers to: a highway-related publication (I); the social and demographic impact area (B); and the twenty-third publication within the category. Reference number IV-15 indicates the fifteenth publication in the model section (IV).

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21. Little, Arthur D., Inc., San Francisco Community Renewal Program (CRP): Purpose, Scope and Methodology, Report to Department of City Planning, August 1963.

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23. CONSAD Research Corporation, Impact Studies: INTRA II, NECTP-243, Pittsburgh, Pennsylvania, February 1970.

SECTION 2

SELECTED STUDIES

I. HIGHWAYS

A. Economic Activity and Industrial Location

I-A-03.

Bardwell, George E. and P. R. Merry, "Measuring the Economic Impact of a Limited-Access Highway on Communities, Land Use, and Land Value," Highway Research Board, Bulletin 268, pp. 37-73, 1960.

Summary

Impacts of bypass, limited-access highways (U.S. 85 and 87) on business activity and land use and value in bypassed communities are assessed. Rates of economic change and highway economic impacts are estimated from annual sales tax data (1946 to 1957) for five industry groupings. Land value and land use are examined using property sales records in the "before" and "after" time periods. Three locations are analyzed: land along new highways; old highways; and improved old highways.

Study Area and Investment

U.S. 87, a north-south, limited-access highway through Denver, was constructed from 1949-1956. The road bypasses seven small towns outside Denver; economic activity in one of these towns (Brighton) is examined to evaluate highway impact. Land sales data were examined over the entire length of the new and old routes. Portions of U.S. 85 (the old route) merge with 87, while other segments have been improved or remain unimproved.

Methodology

Sales tax collections were used to measure business activity in Brighton and in the state as a whole from 1946 to 1957. Five industry groups believed to be highway associated were defined: (1) apparel; (2) automotive; (3) food; (4) furniture; and (5) general merchandise. Graphic representations for each group were constructed and rates of change for the town and state were compared.

Land value was determined by sales price per acre during the before and after periods, defined by the date of approval of the highway project by federal and state authorities. Land types considered in analyzing sales prices included: improved or unimproved land; use (grazing, dry farm, irrigated, or "rurban"-suburban, as determined by assessed valuation); and location with respect to the new highway, the improved highway, or the old highway.

Sales price per acre was related to distance (in miles) of parcel from an urban community; size of parcel in acres; and land type.

Impacts

Sales tax data indicated that the bypass did not significantly affect the general level of business activity in Brighton. Of the five industry groups studied, only the automotive group showed an immediate decline in gross sales (about 13 percent per quarter for one year). There was subsequent improvement in this activity and it was expected to reach the level existing before the bypass. Rates of change in other industry groups were comparable to state rates, and appeared to be independent of highway construction.

The sales price per acre of nearly all types of rural land (whether improved or unimproved) increased in the "after" period. There were greater value increases among parcels located along new highways than along old improved highways, and also greater increases for unimproved vs. improved land. The number of transactions alongside new highways was substantially larger than along improved old highways.

The average parcel size decreased during the "after" period, and the average distance from a metropolitan community was greater for land sold during this time period. Examination of land type in relation to these two variables showed that for grazing land and "rurban"-suburban land parcels there was no discernible pattern during the "before" period while in the "after" period there was an inverse relationship between sales price per acre and parcel size and distance from nearest urban area. This is interpreted by postulating that growth of a community occurs in areas made accessible by improved highways, and that as land becomes scarce, parcels available for purchase are farther from the community. Examination of similar relationships among dry farm land and irrigated land parcels were obscured by proximity of portions of the new and old highways.

I-A-04.

Bleile, George W., and L. Moses, "Transportation and the Spatial Distribution of Economic Activity," Highway Research Board, Bulletin 311, pp. 27-30, 1962.

Summary

Industrial relocation, expansion, and new location, in the Chicago Metropolitan Area from 1950-1960 are classified by radial distance from the central business district (inner city, city fringe, suburban rings). Forces affecting relocation decisions are discussed and hypotheses of locational change are tested.

Study Area and Investment

A trend toward dispersion of manufacturing activity away from the inner city was evident in the Chicago Metropolitan Area during 1950 to 1960. Transportation is assumed to have influenced this trend, although no specific highway investments are cited.

Impacts

Examination of industry relocations from 1950 to 1960 by distance from city core led to four major conclusions: (1) Distance from the central business district (CBD) does not play a role in the decision to relocate. Relocation of firms out of the CBD is numerically large, but in terms of percentage, no different from other metropolitan areas. (2) Firms located closer to the CBD are less likely to expand facilities there. (3) Industry movement from the CBD is generally to the city fringe (not to suburbs). (4) The "seed-bed" hypothesis -- that the inner city acts as a spawning ground for new small firms -- is empirically supported. Small firms are attracted to the city because of the ready availability of leased space; loans provided by a competitive banking environment; auxiliary business services; and a large pool of low-wage, unskilled labor.

Conclusions

The relocation decision is influenced by two conflicting sets of forces: those favoring relocation (e.g., lower-priced land and improved transportation); and those opposing relocation (e.g., established labor supply and ties with firms providing services). Friction of these forces tends to minimize the relocation distance, and may account for the small (5 mile) median relocation distance found for this area. This friction is also reflected in the trend to move to the urban fringe (within the political boundaries of the city) rather than into the suburbs.

I-A-05.

Bone, A. J. and Martin Wohl, "Massachusetts Route 128 Impact Study," *Highway Research Board*, Bulletin 227, Washington, 1959.

Summary

The study examines land use changes (industrial and residential) along a circumferential highway, Route 128, in the Boston Metropolitan area and evaluates the impact of these changes on the metropolitan area as a whole. Route 128 encouraged Boston area companies to relocate in newly accessible suburban locations; it also attracted some new industries. Although the metropolitan area as a whole experienced economic growth, the central city lost employment. The study also found that land use and values near the highway were influenced by its construction.

Study Area and Investment

Route 128 extends for 60 miles in a semicircle on the western side of Boston, approximately 10 miles from the central business district. The highway, constructed in stages from 1933-51, originally cut across large sectors of undeveloped land between older radial highways.

Exogenous Factors

Timing was a major factor in Route 128's economic impact. The highway made suburban land accessible at a time when many of Boston's businesses were expanding to a point where they could no longer operate efficiently in expensive yet obsolete buildings in the cramped central business district. Some topographic features and zoning regulations may have reduced the highway's effect on residential development.

Impacts

Industrial firms within one mile of the highway were classified into four types - production, distribution, service, and research and development. Their origin was examined to establish whether they were new to the area or had relocated from other parts of the metropolitan region. Production and distribution firms accounted for about 80 percent of total development in terms of capital investment, employment, and number of firms. Over 78 percent of all Route 128 firms had relocated from the greater Boston area (primarily the central city). In examining net changes in industrial development, it was estimated that the Boston area gained about $80 million in capital investment and 12,000 new jobs. The central city, however, suffered a net loss of approximately 1,500 jobs.

Changes in residential development and land values in two towns through which Route 128 passed were also evaluated. Residential development (number of units, density of units, and value of land) in town areas near the highway or near interchanges were compared to control areas. Land values and density of units were significantly higher for the highway zones than for control zones; access to interchanges was more important than general proximity to the route. The number of new units constructed and the rate of construction depended upon the existing amount of development. In the more developed of the two towns, the highway had a smaller impact on residential development, although land value increases were equivalent or greater than those in the lesser-developed town.

A survey of Route 128 firms to establish factors that influenced their site selection showed that of 15 commonly cited factors, the most important were: (1) land for expansion; (2) labor market; (3) employee access; and (4) commercial access.

Methodology

Data for the study were collected through mailed questionnaires and direct interviews. Residential and land price data were acquired from tax assessors' records, and building and occupancy permits.

Conclusions

Route 128 stimulated outward relocation of existing industry. Thus, suburban expansion occurred partly at the expense of the central city. Since, however, the highway also attracted some new industry, the metropolitan area as a whole experienced a net increase in industrial activity.

The highway stimulated residential development in the towns through which it passed. Industrial and residential development can be ascribed, in a general way, to an increase in congestion-free "regional access" resulting from the construction of Route 128.

1-A-06.

Bowersox, D. J., "Influence of Highways on Selection of Six Industrial Locations," Highway Research Board, Bulletin 268, pp. 13-26, 1960.

Summary

Plant location procedures used by six Michigan industrial firms in 1957-58 are described. Surveyed firms considered highway facilities important, but not critical in their decision making. General trends in the use of highways by industry, and specific considerations in plant location (e.g., access to markets and space availability) are discussed. Several examples of significant industrial development after highway construction are summarized (e.g. Route 128 and the New York Thruway).

Study Area and Investment

The six plants in the study were located adjacent to free-access roads in Michigan. They had all relocated after 1950 but they varied significantly in size.

Impacts

All firms recognized a need for proximity to highway transportation, but in only one case was proximity considered critical. Similarly, the type of highway was not considered significant, except in one case. Potential advertising or public relations benefits of location near a highway were considered unimportant.

Methodology

Field interviews were conducted with the one or two members of each firm who were most instrumental in the location decision. It is noted that responses contain biases of these individuals, and that elapsed time since relocation may have distorted perceptions of important factors in the location decision. Interview results were checked against records of the Michigan Economic Development Department.

Conclusions

The author concludes that "the typical firm does not fully appreciate the total economic impact of highways on business operations." Realization of highway impacts on cost factors is also limited. However, it is suggested that the national trend toward increasing reliance by industry on trucking transportation and the decreasing availability of industrial space in the central business district will increase general recognition of the importance of highways.

I-A-12.

Connally, Julia A., The Socio-Economic Impact of the Capital Beltway on Northern Virginia, Bureau of Population and Economic Research, University of Virginia, Charlottesville, Va., 1968.

Summary

Changes in demographic, industrial, and land use characteristics in Northern Virginia near the Capital Beltway (Washington, D. C.) during 1950-1965 are identified and related to the Beltway. The Beltway increased suburban industrial and high-density residential development and associated land values. Low-density residential development was not influenced significantly, nor were the values of single-family homes. The Beltway appears to have reinforced, rather than altered, existing trends toward suburbanization. The Beltway interchange areas have emerged as focal points for new and intensive development in Northern Virginia.

Study Area and Investment

The area under study, located south and southwest of Washington, D. C., included Fairfax County and parts of the City of Alexandria in Northern Virginia. The area has experienced rapid growth since 1930. Population grew from 91,000 to 363,000 between 1950 and 1965. Development prior to 1950 was primarily along radial arteries to Washington.

The Capital Beltway was constructed in the early 1950's as a by-pass around Washington, D. C. and as a link to the growing Virginia and Maryland suburbs. Sixty-six miles long, it lies approximately 10 miles from the central city and encircles the most densely populated portions of the metropolitan area.

Methodology

Land use data were gathered from aerial photographs and compared to tax assessment records for consistency. Assessment records were also used to determine property values, with estimated values of building improvements subtracted to reflect true land value appreciation. Three groups were surveyed to determine use of the Beltway: shoppers; residents of apartments near the highway; and industries located near the Beltway.

Impacts

General analysis indicates that the pre-Beltway radial development trend persisted, but a circumferential pattern was added following Beltway construction.

A narrow band along both sides of the Beltway captured the largest share of growth. Development in this area was attributed to the highway. Parts of the study area further away from the highway and the central city experienced low-density, primarily residential, development with no apparent effects from the Beltway.

Land close to the highway and zoned industrial, commercial, or high-density residential increased most in value. Single-family residential land appreciated in value independently of distance to the Beltway.

The Beltway interchange areas have emerged as the focal points for new and intensive development in Northern Virginia. The interchanges contain several multi-family developments, a shopping area, and one of the region's largest employers. Current construction and rezoning indicate intensive uses are continuing.

The major burden of controlling the impact of the Beltway on land development was placed on traditional zoning policy. Zoning boards were not able to withstand consistently the intense development pressure generated by the Beltway.

The influence of the Beltway on industrial growth was reflected in responses to the industrial survey. Some 80 percent of the managers questioned stated that either the Beltway route or access to the route was a significant factor in site selection. Beltway sites apparently were preferred in spite of limited access to blue collar workers. However, a survey of workers in Beltway apartments revealed that labor market boundaries were expanded by construction of the highway. More than 50 percent of those interviewed commuted to work via the Beltway. Most respondents viewed the Beltway as a connector to arterial roads into and out of the city.

Suburban retail sales in Northern Virginia showed no consistent change as a result of the Beltway. Shopper interviews revealed only a small percentage of Beltway users. Thus the Beltway does not appear to have expanded suburban market areas in any dramatic fashion.

Conclusions

The Capital Beltway was an important factor in the development of Northern Virginia. Local conditions (saturation of land east of the Beltway and rapid growth of the Washington, D. C. area as a whole) made the impact of the highway greater than what it might have been otherwise. The Beltway apparently did not cause new growth, but rather helped determine its location. Economic and residential decentralization, a dominant trend prior to construction of the highway, continued subsequent to construction. The Beltway allowed more diffuse, rather than strictly radial, suburbanization.

I-A-24.

Fromm, Gary, ed., Transport Investment and Economic Development, The Brookings Institute, Transport Research Program, Washington, D. C., 1965.

Summary

The role of transportation investments in stimulating economic development and the normative design of national transportation policies to achieve social and economic goals of undeveloped countries are discussed in a series of articles. The discussions cover policy strategies for maximizing national output and for optimizing interregional economic and demographic distributions. The treatment ranges from purely theoretical to largely empirical, with the majority of articles concentrating on theoretical aspects of economic development.

The first essay (Chapter II) focuses on objectives of transportation given both economic and noneconomic goals and effects. The economic characteristics of alternative transport modes -- economies of scale, capital intensity, flexibility, and so forth -- are examined in Chapter III. The next chapter discusses technological change in transportation and describes some future possibilities for lowering costs and increasing mobility.

Chapter V discusses problems in design of the transport sector of an economic development plan. The next essay outlines a comprehensive, dynamic planning model and discusses its implications for wage, pricing, regional, and transportation policies. A review of the role of transportation in Soviet development follows. The next article suggests that application of regional linear programming techniques should enable countries to plan and manage the development process with greater efficiency.

Chapter IX describes cost-benefit evaluation as a tool in establishing priorities for transport projects. Chapter X explores the implications of different pricing schemes and proposes a multi-part charging scheme for obtaining full cost recovery. Inadequate consideration of financing requirements can have grave consequences on the availability of public investment funds and may create inflationary pressures, discussed in Chapter XI. The final essay examines a decision to construct railroads in Chile.

Conclusions

On a national level, transportation plays a multi-faceted role in achieving developmental objectives. Not only does it permit the necessary transfer of goods and people between and within production and consumption centers, but it also shifts production possibilities by altering relative cost factors through decreased transport costs. Transportation is also a consumption good in itself. The selection of a specific mix of transport modes can heighten any of these roles and their subsequent impacts on development.

The derivation of a comprehensive transportation plan for a developing country involves the recognition of practical constraints in maximizing long-term national productivity and welfare. The setting of goals should include minimum acceptable gains as well as desired gains for a full range of social and economic objectives.

Finally, it is pointed out that in an already developed country with an existing, effective transport network, new transportation investments -- if they are of standard technology -- alter mobility and relative costs only marginally and therefore do not have a profound influence on the growth or distribution of economic activities.

I-A-25.

Gamble, H. B., D. L. Raphael, and O. H. Sauerlender, "Direct and
indirect Economic Impacts of Highway Interchange Development,"
Highway Research Record, Number 149, pp. 42-55, 1966.

Summary

An analysis of expected economic impacts of the Keystone Shortway (I-80) on Clinton County, Pennsylvania was conducted using a static Leontief input-output model. The basic model consisted of 54 economic sectors, each representing a type of economic activity within the county. The flow of funds from each sector to the others was represented by coefficients derived from a transactions matrix. Previous research results on predicting interchange development provided a basis for evaluating future interchange development in the study area. Direct and indirect economic impacts were derived under two assumptions -- local ownership of the new enterprises or chain (non-local) management.

Study Area and Investment

The Keystone Shortway is a four-lane, limited access, toll-free highway crossing Pennsylvania from Youngstown, Ohio in the west to Stroudsburg, Pa. in the east. The Clinton County portion of the highway was scheduled to be constructed last; four interchanges were planned within the county.

Methodology

Primary 1964 data sources were used to construct the basic economic model, using interview, questionnaires, and sampling techniques. Fifty-four economic activity sectors were identified. A transactions matrix was constructed showing total value in dollars of purchases of one sector from every other sector, and total amounts of money flowing into or out of each sector from the outside world. A set of technical coefficients representing the proportionate distribution of income, as expenditures, to other sectors of the region and to the outside world was constructed from the transactions matrix. Given a set of external incomes to the various sectors of the region and the set of coefficients, the economy of the region could be simulated. The model could be altered by: (1) changing the level of outside sales or export demand; (2) changing the technical coefficients of any economic sector; or (3) adding new sectors to represent new businesses.

Previous research on interchange development identified significant exogenous factors (e.g., topography, distance from key cities, age of interchange) and important endogenous factors (e.g., population at interchange, public utilities at interchange, existing development at or near site) governing the rate of development. Although quantitative relations between these factors and development were not available, the authors evaluated these factors in conjunction with specific data on the four proposed interchange sites, and forecasted four types of development -- a trucking terminal, a 100-unit motel, four service stations, and two new restaurants. Three new sectors were added to the model to represent these establishments. (The trucking terminal was considered a relocation, and a new model sector was not necessary.)

Impacts

Impact analysis was carried out assuming: (a) increase in non-local retail purchasing plus impact of the three new activity sectors when restaurants and motel are under non-local ownership; and (b) the same as (a) except that restaurants and motel are locally owned.

Total economic activity in the county under local ownership of new facilities increases by about $5 million per year; of this, about $2.2 million is new money from outside the county. These external sales generate an additional $2.8 million of economic activity internally, yielding a multiplier of 2.27. Non-local ownership leads to a smaller total increase ($4.7 million) because the multiplier, 2.17, is smaller.

Much of the gain in total economic activity involves counting the same dollar as it passes from one business to another. The net residual benefit or income to households, local governments and nonprofit organizations is a more accurate measure of economic benefits. About 40% of external sales (or 18% of total economic activity generated) accrues as net residual income under local ownership, with the bulk (34%) to households, 4% to local government and 2% to nonprofit organizations.

Gains in the total economic activity generated indirectly are primarily in retail, wholesale, government and industry.

Results are also computed by impact response functions constructed for each one of thirteen aggregated sectors formed from the original 34 sector model. The functions are linear combinations of increases in external income according to service (new restaurants, motels, service stations, and new retail external income) multiplied by coefficients derived from the direct and indirect response of each sector to one dollar of external income from the various new income sources. Calculations using response functions are in good agreement with results obtained from the input-output model.

I-A-26.

Garrison, William L., B. J. L. Berry, D. F. Marble, J. D. Nystuen and R. L. Morrill, Studies of Highway Development and Geographic Change, University of Washington Press, Seattle, Washington, 1959.

Summary

The impact of highways and highway improvements on retail business and residential land use are discussed theoretically and through analysis of a series of case studies. Impacts of highways on customer movement (in connection with retail business location) and on delivery of services are also discussed. Geographical structure is the central theme of these related analyses.

Highways and Retail Business

A review of empirical and theoretical work on the spatial ordering of urban land use suggests that the retail business structure of a city has two basic conformations: string street development and clusters (hierarchically structured from central business districts (CBD) to neighborhood facilities). Analyses of business location in Spokane, Wash., Phoenix, Ariz., and Cincinnati, Ohio and along U.S. 99 in the State of Washington show consistent patterns in terms of these two conformations for different types of spatially associated business. In particular, a group of business types which tend to co-locate on "automobile rows" are identified; another group of highway-oriented businesses are successful only when located on urban arterials or on highway strips.

Impact of highway changes on business establishments is discussed with particular reference to Marysville, a small city in Washington bypassed in 1954. A variety of sensitivity indices are used to characterize the short-run sales records of business establishments in Marysville before and after highway re-orientation.

The conclusion drawn from the empirical studies is that almost without exception, retail business location patterns are determined by the network of highways. They generally conform to efficient arrangements of specialization dependent on transportation availability.

Highways and Urban Residential Land Use

The relation of residential spatial structure to the urban road network is discussed in terms of general models of urban growth and structure and in terms of factors determining residential site selection by individual households. A number of case studies are reviewed, particularly a study based on travel diaries in Cedar Rapids, Iowa. The relatively brief discussion of the many factors involved in residential site developments concludes that it is difficult to measure the effect of highway improvements on residential land use within a city.

Customer Movement and Retail Business Location

The same primary data on Cedar Rapids are used to define how people move to obtain services of retail business. The spatial relation of businesses to their customers' home locations, and the association of a business with other businesses as established by customers' habits of shopping for more than one item on a single trip, are examined in detail. Empirically, it is found that customer travel resembles the expected pattern but with some important exceptions. The average distance traveled for low order goods is much greater than expected. Persons travel through low level centers to high level centers to purchase items available at low level centers. A combination of purposes often motivates longer trips. Analysis of shopping stops on multipurpose trips shows a wide range of association only generally resembling the spatial arrangement of business establishments.

Highways and Services

Introductory discussions and review of pertinent literature on the relationship of highways, service areas, and the movement of persons with particular reference to demand for physician care are followed by an account of empirical observations of movement of persons to physicians in Western Pennsylvania and Seattle, Washington. These studies suggest that producers of services gain most from highway construction in areas where trade and consumption may increase. Consumers pay more, but receive more, and possibly better, care. Where trade and consumption are relatively inelastic, consumers gain most through transport cost savings (primarily vehicular benefits). New highways help central cities to retain expenditures of wealthy suburban residents but also serve to aggravate the relative disparity between rural-small town and large urban center; at the same time, they help rural-small towns to consume more easily the more specialized services.

I-A-27.

Grossman, David A. and M. R. Levin, "Area Development and Highway Transportation," Highway Research Record, Number 16, pp. 24-31, 1963.

Summary

Highway effects are examined for three major types of economically distressed areas: manufacturing-based regions (the textile cities of New England); mining regions (areas in Pennsylvania, West Virginia, and Kentucky); and agricultural regions (Appalachia). Stimulation of economic growth by highways is slight in mining or agricultural regions. However, case studies show that manufacturing areas can be stimulated when a highway provides access to a nearby metropolitan area with a more diversified economy.

Study Area and Investment

The New England textile industry has experienced continuing employment declines since the 1920's due to automation, relocation, and international competition. Four former textile cities in Massachusetts were examined: Lowell and Lawrence (approximately 25 miles from Boston) and Fall River and New Bedford (40-50 miles from Boston). These cities were connected by radial expressways to Route 128, a circumferential highway 10-15 miles from Boston.

Distressed mining areas generally suffer from resource depletion, competition from other raw materials, and from effects of increased mechanization. Some areas also have mountainous topography (e.g., eastern Kentucky and West Virginia) and are relatively inaccessible.

Mechanization and surplus agricultural production may produce distressed agricultural areas. In some instances, e.g., southern Appalachia, whole regions fail to remain competitive in the national agricultural economy.

Other distressed areas include areas formerly dependent on the railroad industry, on discontinued government or military installations, and some resort or recreation centers.

Impacts

Highway improvements in Lowell and Lawrence increased significantly the radius of easy commuting for workers living in these areas and enabled them to hold jobs in the growing electronics and research industries along Route 128. These improvements also increased the attractiveness to manufacturers of industrial sites in these areas by making accessible a large labor force in close physical proximity to Boston.

The cities of Fall River and New Bedford were also linked to the Boston area by radial highways. However, their greater distance (approximately twice that of Lowell and Lawrence) has diminished the spillover of industry, suburban residents, and other favorable economic effects from metropolitan Boston.

Mining areas are often small and lack urban facilities and services which attract manufacturing industries; improvement of their economic base is difficult. Areas within reasonable distance of metropolitan development can sometimes be helped by highways (e.g., eastern Pennsylvania). However, improved highways generally have slight economic impact.

Only a small role can be played by highways in meeting the enormous needs of distressed agricultural areas. Agricultural areas are often low-density regions, with small urban areas and topographical obstacles to accessibility. Expressways in such areas have low benefit-cost ratios. Improved secondary roads may be worthwhile undertakings in such areas.

I-A-28.

Harrison, J. W., "Methods Used to Study Effects of Lexington City, Virginia Bypass on Business Volumes and Composition," *Highway Research Board*, Bulletin 189, pp. 96-110, 1958.

Summary

A case study of a rural county in Virginia is used to describe and assess methodologies for determining economic effects of a bypass highway. Three study areas comprising a town of 6,500 people bypassed in 1955 are contrasted with four control areas elsewhere in the county. Business volumes of three selected retail trades were examined using the "before and after" methodology and the "study area-control area" approach. The author concludes that the latter provides a more complete analysis of economic highway impacts.

Study Area and Investment

The study area (Rockbridge County, Va.) is a broad valley region with agriculture and manufacturing the main income sources. The investment studied was a bypass highway opened in 1955.

Impacts

Business volumes in the downtown area generally declined, due to a locational shift toward fringe areas. The three retail trades examined showed the following trends:

Service stations in the principal (downtown) study area suffered a loss of sales; those near the fringe area recorded increases greater than for any of the control areas.

Automotive dealers showed increased volumes and income in all study areas. Control area comparisons were limited due to differences in the nature of individual businesses.

Restaurants appeared to be influenced by non-highway factors not readily identifiable from data collected in the "before and after" study. It is suggested that this business may be insensitive to highway changes.

Methodology

Data used were: business license applications; county files providing details of business type, location, ownership, date begun, gross income, number of employees, and rental value; and annual gasoline sales. The trades chosen for analysis were believed to be those most likely to reflect impacts of the highway.

Linear equations and regression analysis techniques were used for data analysis. A price index was developed to account for general economic trends. The author points out that it is difficult to isolate highway impacts; the data collected in this study were not sufficient to elucidate many causal factors. Additional data sources and a longer study period are recommended for future analyses.

I-A-29.

Horwood, Edgar M., R. R. Boyce, L. L. Randolph, and D. F. Rieg, Studies of the Central Business District and Urban Freeway Development, University of Washington Press, Seattle, Washington, 1959.

Summary

Changes in the Central Business Districts (CBD) of a broad cross section of U.S. cities are examined from 1946 to 1958. Relative economic activity in the CBD, as measured by retail sales and office space, declined during this period. The probable impact on the CBD of the urban freeway system (under construction in 1958) is assessed from freeway physical characteristics, geographical patterns, and general relations of highways to CBD economic activity.

Methodology

The CBD core and the CBD frame are defined and differentiated in terms of land and site utilization, building types, vertical and horizontal components of growth, business linkages, parking space, transportation modes and foci, and type of boundary determinants. Changes in retail and office space in the CBD were analyzed for a broad section of American cities utilizing U.S. Census of Business statistics and standard correlation techniques. Similar analyses were conducted for electrical utility offices and banking. Additionally, a questionnaire survey of the 100 largest insurance companies yielded about 70 usable replies on locational decisions.

Interactions between changes in CBD characteristics and urban freeway systems were explored by analyzing the physical characteristics of the highway networks (radials, circumferentials, and inner-distributors), their geographical pattern, and their probable impact on CBD activities. The analysis is generally qualitative.

1. Changes of Commercial Characteristics of the CBD (1946-1958)

a. Retail Business

Considering the vast geographical and economic differences between regions of the country, there is comparatively little difference in CBD retail sales per capita for different cities. The percentage of CBD to total city sales decreases as city size increases, but only slightly in cities above 150,000 population. The greatest change in the shift of sales from the CBD to outlying areas occurs as cities approach about 150,000. From 1948 to 1954 there was a general decline, in terms of constant 1948 dollars, of CBD retail sales ranging from 1 to 7% in urban areas of 100,000 people to 14% in those of 1 million. During this period there was also a substantial decrease in

CBD sales per capita ranging from 14% in areas of 100,000 to 28% in areas of 3 million people.

b. Office Space

There was a general increase in central office space between 1946 and 1956, amounting to 1 or 2% in a city of about 200,000 and about 12% in a city of 3 million. However, per capita office space downtown decreased by approximately the same amount. In 1956, an urbanized area of 1 million people added office space at the rate of 3 square feet per capita; a city of 2 million added just under 5 square feet per capita.

Cities high in central place importance (e.g., regional capitals such as Denver, Atlanta, San Francisco, and Seattle) which are not generally part of large conurbations (i.e., grouped cities like those along the Atlantic seaboard) had considerably more office space than average.

Cities with considerable less office space than average were either located in areas with a declining economic base (e.g., Scranton and Reading), or located within the area of economic dominance of a much larger city (e.g., Providence), or were predominately manufacturing cities (e.g., Detroit).

c. Insurance Companies

Of the 69 companies reporting, 63 moved headquarters or regional offices from the CBD core and 6 from the CBD frame between 1946 and 1958. No company moved from an outlying location to the CBD. In fact, 60% of all moves were to outlying areas.

Fifteen of the companies moved their headquarters office during the period from 1946 to 1958. Of these, 4 moved to the suburbs of a city, 2 to incorporated areas over five miles from the central city, and 9 to an incorporated area adjacent to a central city. Areas of comparatively dense residential settlement were considered more favorable for new offices than less built-up unincorporated areas.

Little relationship exists between city size and the degree of suburbanization of insurance company offices. In the case of large cities, the extreme concentration of many insurance headquarters offices in the CBD core of the eastern seaboard insurance centers tends to offset, statistically, suburban movements in other cities of the country.

On the basis of the companies responding to the survey, the insurance industry has decentralized approximately 40% from the CBD core and 30% from combined central locations (CBD core plus CBD frame) between 1946 and 1958.

d. Banking

As a city increases in population, both banking outlets and deposits show a definite increase in all location zones, but at differing rates. Larger cities have a smaller percentage of total city deposits in the CBD core, but even the largest cities have over 75% of total city deposits in downtown locations. Banks with smaller deposits are most often found in suburban locations, whereas banks with very large deposits are almost always located in the CBD core. In any given metropolitan area, total deposits in distance bands from the CBD core appear to be inversely related to distance from the CBD.

II. Urban Freeway Systems and Their Impacts

a. General Impacts

Developing (1958) freeway systems are composed of three distinguishable elements: radials to serve intercity travel and the centrally oriented intraurban trip; circumferentials to serve as bypass routes and meet trip desires between outlying centers; and inner-distributors to collect and distribute traffic to and from radials and to serve as inner city bypasses.

The CBD frame, in contrast to the CBD core, is primarily dependent on external linkages, and its development will be substantially affected by freeway routes and interchanges. These will alter establishment linkages, remove large quantities of central land from the market, and sever homogeneous business clusters. At the same time the inner-distributor freeways cutting through the CBD frame will increase transportation centrality for warehousing, wholesaling, and service industries characteristically occupying frame locations. The CBD frame will probably show greater highway impacts than the CBD core.

b. Specific Impacts

No correlation was found between level of sales in the CBD and degree of urban freeway development in 1956. This may change as the freeway system is completed.

Among insurance companies responding to the questionnaire, all companies establishing new offices chose locations adjacent to major arterials or within a mile of a major arterial. Seven of fifteen new offices were located with frontage on arterials.

Most banks located in outlying areas of an urban center are found on or near state or interstate highways. This coincidence is probably more indicative of an attachment of banks to commercial districts on these routes than to the highway itself.

I-A-10.

Horwood, E. M., C. A. Zellner, and R. L. Ludwig, "Community Consequences of Highway Improvement," National Cooperative Highway Research Program Report 18, 1965.

Summary

Economic impact studies published prior to 1965 on non-user or community consequences of highway improvements were reviewed according to type of investment (bypass, circumferential, urban radial freeways). Studies within each investment category were analyzed in terms of methodology, indicator variables, impact areas addressed, and findings. A computer-based impact classification system was developed to assist in comparative analysis. A mail questionnaire survey and field interviews of highway planners in selected states were used to assess the utility of such studies in highway planning.

Study Area and Investment

Twenty four studies of bypasses affecting 72 communities of varying sizes were reviewed. Six studies of urban circumferential highways in metropolitan areas (Lexington, Ky.; Louisville, Ky.; Minneapolis-St. Paul, Minn.; Washington, D. C.; Baltimore, Md.; and Boston, Mass.) were summarized. Urban radial freeway studies included highways in four major metropolitan areas -- Houston, Dallas, San Antonio, and Atlanta.

Impacts

Analysis of results of bypass studies showed that communities with population of 5,000 or more were better able to adjust to economic changes induced by a bypass than were smaller communities. Highway-oriented businesses (food, fuel, and lodging) were most strongly affected; service stations and restaurants appeared to adjust more easily than motels or hotels. Sales of non-highway-oriented retail businesses (e.g., apparel and furniture) in bypassed communities generally increased after construction of the new highway. Apparently, loss of sales to transients was compensated by the extended trade area provided by the new road. General economic indicators (land use, property values, employment, industrial development) were also briefly summarized.

The general conclusion drawn from bypass studies (though substantiated in only one case) was that bypassed towns within 15 to 25 miles of larger areas along the same highway suffer substantially; conversely, the larger or more centrally located communities along the transportation system are probably substantial beneficiaries of highway improvement, even though bypassed, at the expense of their smaller sister cities.

Impacts of urban circumferential roads included a significant reduction in agricultural acreage, and rapid and intensive development along belt routes, with commercial land showing the greatest increase in value. Land use, land value, motor vehicle registrations, average daily traffic, and gasoline sales were used as impact indicators.

An analysis of urban radial freeway studies showed that land value increases were largest for vacant or unimproved land; that land value computed with improvement value deducted increased in value two to three times more than that of land inclusive of improvements; and that in the majority of cases, the value of land abutting the highway exceeded that of land further removed as well as land in control areas.

Methodology

The authors identified several important factors in comparing bypass studies. These include: time span studied; comparability of facilities; selection of geographic boundaries; and scope of economic change considered. The lack of standardization in treating these and other factors in impact analysis makes comparison of studies difficult. In all studies a major problem was isolating highway impacts from other influences.

Radial corridor studies (as of 1965) had three general shortcomings -- use of assessed valuation as a criterion, bias of the sample of land values, and nature of control areas.

I-A-33.

Kiley, E. V., "Highways as a Factor in Industrial Location." *Highway Research Record*, Number 75, pp. 48-52, 1965.

Summary

A nationwide questionnaire survey of newly located business establishments between 1955 and 1959 sought to determine the most important factor in plant location decisions for a variety of industries. The single most frequently mentioned factor was proximity to good highways, but market, labor, and land availability were also rated important. Responses indicate that the relative importance of locational factors varies sharply from industry to industry. The results also reflect a pronounced outward movement of industry from central city to suburban and rural locations.

Study Approach

A questionnaire was mailed to some 4,150 establishments which had: (1) begun business for the first time; (2) opened a new branch plant; (3) moved to a new location; or (4) expanded at an old location. The sample covered 22 SIC groups, including a cross-section of manufacturing, wholesaling, distribution, and research and development firms. Slightly over 36 percent of the questionnaires were returned; 1,363 were considered responsive and were utilized in the statistical analyses of the study.

Each questionnaire contained the following 13 factors commonly considered in business location decisions: availability of suitable land, proximity to markets, availability of raw materials, abundant water supply, proximity to good highways, availability of rail service, proximity to related industry, abundant labor supply, favorable tax structure, existence of building at site, favorable leasing or financing, nearby vocational training facilities, and community cultural-recreational assets. Recipients were asked to select the five most important factors in the selection of their sites. The survey included several other questions on employment and transportation, as well as three essay-type questions.

Findings

The four factors mentioned most frequently were, in order: proximity to good highways, abundant labor supply, availability of suitable land, and proximity to markets. Essay responses showed that highway proximity reflected a desire for effective transportation of goods, employees, and customers, as well as advertising provided by highway exposure.

Rail service, raw materials, favorable tax structures, favorable financing, abundant water supply, and proximity of related industry were considered important by some industry groups, but their relative importance varied sharply among industries.

Survey results show a pronounced trend toward decentralization of industry. More than 48 percent of the respondents were located in small towns or rural areas, 26 percent in suburbs, while only 24 percent were in cities. However, large, market-oriented businesses, such as the wholesale trade group, were concentrated (78 percent) in or near large cities.

About half of the respondents had moved from a different location. Of these, 23 percent moved from city to rural areas, and 24 percent moved from city to suburbs, while only 22 percent moved from one city location to another. Almost no firms moved from outside cities to city locations.

Conclusions

The survey suggests that a small number of factors dominate the location decisions of most business enterprises, and that highway proximity is one of them. Increased accessibility provided by highways combined with available markets and labor helps make specific locations attractive to businesses.

The outward trend in industrial location coupled with the importance attached to availability of suitable land, suggest that suburban and rural areas are attractive to industry because they contain relatively large and inexpensive parcels of land. Highways, perhaps, catalyze the movement by making outlying areas more accessible.

I-A-34.

Kinnard, William N. and Z. S. Malinowski, *Highways as a Factor in Small Manufacturing Plant Location Decisions*, University of Connecticut, 1961.

Summary

A conceptual framework for analyzing location decisions of industrial firms, a review of the findings of previous studies in this area, and a case study of manufacturing firms in the Hartford economic area are presented. Executives of seventy-six manufacturing firms located in the Hartford area between January 1953 and June 1959 were interviewed. An additional 124 manufacturing firms were queried by mail about their new plants. The two sets of data were combined to develop a statistical picture of the pattern of highway proximity and access actually achieved by firms with different plant or location characteristics.

Study Area and Investment

Hartford and twenty surrounding communities in north-central Connecticut comprise a prosperous, medium- to high-density urban center of one-half million people, heavily industrialized and rapidly growing at the time of the study (1960). Industry was concentrated in small (less than 50 employees) metals and aircraft parts firms with a continuing trend in that direction. The existing network of urban highways in and near Hartford was studied as a factor influencing locational decisions. Other factors affecting location decisions, but considered exogenous in the study, were zoning and sewers in the 21 towns and several bridges.

Methodology

Newly located (120 firms) or relocated (135 firms) in the Hartford area from 1953 through 1959 were canvassed by mail. Two hundred firms responded; 76 were interviewed about their locational choice. These included primarily the larger responding firms, those which had relocated (vs. newly formed firms), and metals manufacturing firms outside the Hartford area. The interviewer did not stress highway factors, but sought the respondents' freely expressed opinions of important factors. Interview results were correlated with distance of the plant from the highway and price paid for land and/or building (whether purchase or rental price).

The authors define three levels on which the location decision takes place: (1) primary - factors which delineate a broad region; (2) secondary - factors narrowing the decision to one or a few communities within the region; and (3) tertiary - actual site selection. Also, three types of selection factors are identified: market access; cost; and "non-economic." Highway transportation is typically a cost factor at the tertiary level.

Impacts

In general, the network of existing roads, rather than any one highway or road, seemed to influence the locational decision process. Firms tended to take the highway system for granted. What a firm maintained that it did in selecting a plant site and what field inspection indicated was often at variance: metals manufacturers generally claimed to consider highways as an important factor in location, but non-metals firms were actually more likely to locate closer to a highway.

Many firms did not need particularly good access, and found avoidance of congestion associated with highway locations more significant in plant site selection. However, if all other factors were essentially equal, manufacturing firms tended to choose a location offering best highway access, or to reject a location offering poor access or high congestion.

Highway access did not rank high among reasons given for selection of plant site; nor were highway access and/or reduced congestion significant reasons for leaving a previous manufacturing plant location. Manufacturers will rarely pay a premium for an on-highway site.

Access is measured quite differently by firms with varied operational requirements (e.g., "good access" may mean direct entry onto a high-speed dual highway or a site over two miles from the nearest state or federal highway).

Larger firms are more sensitive to highway access as a location factor; they are most likely to place great weight on highways or to ignore them completely. They are also most likely to locate closest to or farthest away from a highway.

Manufacturers purchasing space tend to weigh highway access more heavily than firms renting space.

I-A-36.

Kuehn, John A. and Jerry West, "The Ozarks: Highways and Regional Development." Growth and Change: A Journal of Regional Development, Vol. 2, No. 3, pp. 23-28, July 1971.

Summary

The role of highway development in regional planning for depressed areas is discussed based on relations between highway type and type and amount of industrial employment. Data on the Ozark region from 1954 to 1963 show highways not to be a crucial factor in explaining income variations or labor force characteristics. Access and local roads have a somewhat higher correlation to income. The study challenges the hypothesis that highways generate economic growth. It suggests that economic development depends on many regional characteristics and that highways should not be the focus of regional planning for depressed areas.

Study Area and Investment

The Ozark region includes parts of Missouri, Arkansas, and Oklahoma. The area is characterized by low per capita income, dependence on agriculture, high out-migration, chronic unemployment, lack of economic opportunity, inferior education, and inadequate community services. Federal decision making exogenously effects the area through the allocation of development money and programs. The highway types looked at are classified by type: multilane, federal, state, local, unpaved, access, and feeder roads.

Impacts

Impacts are per capita income, labor force characteristics and type of industry for entire region. Changes in these factors over the period 1954-1963 were correlated with number of miles of each type of multilane, federal, state, local, unpaved, access, and feeder roads. Highway data were collected from maps and state highway departments. Rank correlation was used to relate mileage by type in each county to per capita income and labor force characteristics. Five year time lags were used in calculating highway effects.

Highways were only moderately related to per capita income. Access and local roads showed a somewhat higher correlation. Highway types showed almost no correlation to labor force characteristics. Access highways (primarily federal) were slightly related to chemical, transportation equipment and metal aircraft industry levels. Local unpaved roads were slightly correlated with the level of the food processing industry.

I-A-40.

Maiolo, John R., ed., Highways and Communities, Pennsylvania State University, University Park, Pennsylvania, June 1966.

Summary

Three articles summarize and consolidate findings of projects conducted under the Pennsylvania State University research program. The discussions cover prediction of growth at interchange locations; design of land use plans for highway protection at interchange locations; and identification of social conditions and community structures conducive to regulation of roadside growth. The focus of the studies is the Interstate Highway System, planned to include 1,574 miles of limited access highway in the state, along with 217 interchanges.

Methodologies, Investments, and Impacts

Monroeville Case Study

An historical case analysis was conducted in Monroeville, Pennsylvania from 1949 to 1957 when three major highway developments were completed: the Greater Pittsburgh Interchange of the Pennsylvania Turnpike (opened in 1951); a four-lane highway connecting the town to Pittsburgh (opened in 1953); and a route through Monroeville, widened to four lanes in 1957.

Before and after and control area methodologies were used to assess social and economic impacts. Sources for the study were local, county, state, and federal government data; interviews with householders and businessmen; and field observations.

Government expenditures and school expenditures showed large increases in Monroeville from 1950-1957 -- 988% and 588% respectively. The value of real property rose 336%, as compared to a control area increase of 74%. Population increased in the study area by 119% as opposed to 25% in control areas (1950-1958). All other variables showed significantly larger increases in the study area, and these included: number of real estate transfers (212% vs. 3%); power connections (104% vs. 45%); taxes levied for all purposes (306% vs. 76%); and taxes for real estate (311% vs. 73%). A comparison of change in communities with and without highways in this area of the state also indicated significantly larger increases in areas with highways.

Economic Development at Interchanges

Economic development at 36 non-urban interchanges of the Interstate Highway System in Pennsylvania located beyond the urbanized area peripheries was assessed. Data were obtained on the following variables: type of interchange; average daily traffic (ADT); distance to nearest urbanized area; age of interchange; topography; population; and market value characteristics.

An average of 1.9 units of development per interchange were recorded. The total for the 36 interchanges included 20 service stations, 15 restaurants, 11 motels, 10 industries (all located at one interchange), and 12 'other' new establishments. Average daily traffic (ADT) on Interstate routes was a poor indicator of development. However, ADT on the cross-route was the best single indicator of total highway-oriented development. Twelve intersections having above average ADT on cross-routes accounted for 62% of all development.

Topography and distance to the nearest urban area were also significant variables. In general, development tended to be at interchanges nearest to an urban area. Of 19 interchanges within 14 miles of an urban area, all but 2 had some development. In contrast, only 3 of 17 interchanges located more than 14 miles from an urban area experienced some development.

Topography appeared to be a significant factor. Excessive slopes (over six percent average slope) tend to minimize development. Thus, average development was only 0.5 units at interchanges with excessive slopes, but was 3.0 units at interchanges with 2-3 percent slope.

Substantial economic development occurred during the first year after an interchange was opened. Development occurred at a slower rate in subsequent years. Gasoline stations showed decreasing development rates after the first five years following interchange opening.

Community Impacts

A third study addressed unplanned development along highway rights-of-way and at interchange sites and its relation to community structure. Case studies were conducted in Monroeville (14 miles east of downtown Pittsburgh); Blairsville (45 miles east of Pittsburgh); and in four suburban interchange communities near York, Pennsylvania.

The research was incomplete at time of reporting; however, certain findings on community organization, social stratification, and population are presented and interpreted.

A community complexity index was defined as the weighted sum of a series of factors considered necessary for the development of a master plan (e.g., land subdivision control, sewer authority, planning commission, etc.). Communities on arterial highways in Pennsylvania averaged higher scores of the index than non-highway communities. In the case study areas, there were significant increases in the complexity index during the study period, except for some areas of York County.

Population changes during the study period were analyzed in terms of socioeconomic level of those migrating into the community after highway improvement. Statistically significant differences in social class ratings between migrants and non-migrants were found; the influx of new residents tended to raise the overall social class of the communities.

I-A-43.

McKain, Walter C., The Connecticut Turnpike - A Ribbon of Hope, University of Connecticut, Storrs Agricultural Experiment Station, 1965.

Summary

A comprehensive analysis was conducted of the impact of the Connecticut Turnpike using before and after and control area techniques. Impacts examined include economic changes (employment, wages, industry diversification, number and type of manufacturing industries, labor market availability, retail and tourist trades), demographic changes (skill levels), local government and community services, attitudes toward change, and land use and land values. The study covers the period 1950-1962 for most parameters; the highway was opened in 1958.

The turnpike was planned and constructed to stimulate an economically depressed area. The economic impact of the highway, although significant, was not as substantial as anticipated. An attempt is made to analyze factors which inhibited expected economic growth.

Study Area and Investment

The Connecticut Turnpike is a 129-mile, four lane, limited access Interstate Highway, extending in an eastward direction from Greenwich, Connecticut at the New York State line to Killingly, Connecticut at the Rhode Island State line. The 72-mile eastern-most portion of the turnpike was selected for study; it included 23 interchanges and 4 toll stations.

Study and control towns in eastern Connecticut were generally small, with a median socio-economic level. As the textile industry, a main employer, declined in the area over the past several decades, unemployment increased.

Methodology

Study areas included "turnpike towns" (all towns, some portion of which lay within five miles of the turnpike), and the areas immediately surrounding the interchanges. The remaining towns in eastern Connecticut were designated as control areas.

Data were collected from federal, state, and local sources, as well as by field surveys. Industrial diversification was judged by comparing local distribution of employment by industry group with national data. Real estate values were obtained from data on properties sold during a base period (1950-1955) and resold in 1956-1961.

Labor market areas were identified by dividing turnpike and control towns into regional composite labor market areas. Geographic labor markets were obtained for selected firms by constructing an 'equiprobable ellipse' representing the residence locations of 95% of commuting workers. Changes in the size of ellipses or the degree of inclination of the major axis indicated orientation toward or away from the highway.

Results

The Connecticut Turnpike was planned to stimulate manufacturing activity and increase employment. Turnpike towns showed the greatest increase in manufacturing employment (37%) in Connecticut, while state totals remained the same, and control towns showed a slight decline. These changes were most substantial in the year immediately following turnpike construction. 34 new manufacturing firms located in eastern Connecticut between 1956 and 1959 -- 27 in turnpike towns, 7 in control towns. However, the turnpike was not rated as the single most important factor in the location decisions of firms locating in the study area.

Wage increases were greater in the turnpike towns (54% increase) than in control towns (24% increase). The change is attributed to the increase in number of employed persons, the shift from textile to non-textile industry, and the general rise of wages from 1956 to 1962. Turnpike towns showed a greater turnover of industry types than control towns, but industrial diversification remained at the same level. Labor market areas expanded geographically (commuting distance increased) in two-thirds of turnpike towns, while control towns showed no significant change.

Retail sales, measured by tax receipts and number of establishments, increased slightly in the turnpike towns (outside of interchange areas) and declined in control towns. The number of tourist lodging establishments in both areas remained the same, but in the turnpike towns a conversion from cabins to larger motels occurred.

Population growth rates in eastern Conn. were less than state rates from 1940 to 1950; from 1950 to 1960, the turnpike towns equalled the state rate, while control towns lagged behind. Growth was greatest in turnpike towns from 1959 to 1964, immediately after turnpike opening. All towns showed increases in planning commission activity, town revenues, and spending for community services.

A survey of summer residents in eastern Connecticut from 1957 to 1962 showed that the turnpike made the area accessible to a broader population of summer residents. The number and value of summer residences increased in both turnpike and control towns.

Residential property showed a higher average annual appreciation in turnpike towns; however, the proportion of higher priced homes was larger in the control towns. This may reflect a tendency for blue collar workers to live in turnpike towns, while management employees prefer to reside farther away.

Examination of real estate values at four interchange areas in 1958 and 1964 showed increases of from 24% to 188%, the higher increases being associated with changes in land use.

Conclusions

The author concludes that the turnpike had important economic, demographic, land use, and social impacts, but was only one of many interrelated factors influencing economic growth. An inhibiting factor was a labor force shaped by the textile industry, and slow to respond to new economic opportunities.

I-A-45.

Michigan State University, Economic and Social Effects of Highway Improvements: A Summary, summarized by [illegible] Clark [illegible], Highway Traffic Center, East Lansing, Michigan, 1961.

Summary

A summary and evaluation of the findings of seven previous studies of highway impacts are presented. The studies, carried out in the late 1950's, examine the economic, social, and land-use community impacts of three separate kinds of highway improvement: relocations, bypasses, and improved regional highway networks. All were performed in small to medium sized towns in Michigan, and together cover a range of highway-related impacts, including changes in land values, retail sales, population growth, and land use patterns. The consensus of the studies is that highway relocations and bypasses have not significantly decreased business [illegible] in the [illegible] affected, though [illegible] generally [illegible] land uses along the old and new routes.

Impacts and Related Topics

"Major objectives of this work are to determine, through examination of previous empirical studies, whether highway relocations and bypasses adversely affect the communities through which the routes previously passed; whether highway bypasses encourage [illegible]; and whether a highway network influences the land use patterns of a region." Of the seven studies summarized, two concern highway relocations and bypasses.

Two relocation and bypass case studies are examined, involving three highways: U.S.-16, a major commercial and industrial route through a rural part of Oakland County, Michigan; U.S.-23, which bypasses a number of small towns in southeastern Genesee County, Michigan; and U.S.-127, which bypasses rapidly-growing satellite communities of Detroit. Sales tax data from 1951-1958 were used to estimate retail business receipts in each of the bypassed communities, and trends were compared to general state and county economic trends for the period 1950-1958. Retail businesses (including traffic-oriented businesses, such as service stations) in the bypassed towns did not suffer serious losses in receipts. Their business activities were roughly equivalent to state and county trends.

The influence of natural barriers and bypasses on growth patterns in small communities is examined in another study. U.S. Geological Survey maps were used to identify natural barriers resulting from topographical features and developmental patterns for twenty southern Michigan towns ranging in population from 150 to 3,500. Comparisons for different communities revealed that natural barriers impede growth in their direction for towns of less than 400 people, but are not significant obstacles to expansion in slightly larger towns (400-1,500 people). However, if highway bypasses were located along natural barriers, the combination effectively blocked growth for all sizes of towns. Where highway bypasses were located away from natural barriers, they tended to draw growth, creating traffic congestion at interchanges.

The bypass effects on retail trade in six communities of less than 25,000 population are summarized in a third study. Sales tax records were used to estimate business volumes for bypassed communities and the State of Michigan. All of the study towns were located outside large metropolitan areas and had been bypassed several years prior to the analysis. Data revealed that in five of the six communities, retailers made greater gains than the state average. However, traffic-oriented businesses, such as service stations and restaurants, lost trade. Attitude surveys of local merchants indicated that they viewed the removal of through-traffic, particularly trucks, as beneficial.

The final chapter on bypass effects describes the impact of the East Highway Bypass of Flint, Michigan on land values. The 10-mile bypass was selected because it had been in operation since the 1930's and therefore its full effect on the city of Flint would be evident. In the past century, Flint had grown from a lumbering town to a manufacturing center and finally to an automobile industrial complex. The study evaluated land use and value changes in relation to highway improvements using property sales data from 1920 through 1951. Land adjacent to the highway, land within one-half mile of the highway, and all other property east of the highway (as a control) was examined.

Data on property sales showed that unimproved parcels abutting the highway experienced a consistent three-fold increase in value from 1920 to 1950. Property in the other two zones showed no consistent trend, with some parcels increasing and some decreasing in value. On improved property, value was related to intensity of use rather than to proximity to the highway. These results indicate that although a relationship exists between highway proximity and property values, other influences can override highway-induced value changes.

Conclusions

Findings of these studies suggest that highway bypasses do not affect adversely retail trade in towns located on the previous routes. Results showed that bypasses stimulate downtown retail business, with the exception of traffic-oriented businesses such as service stations and restaurants. It is suggested that growth may occur because relocations make downtown stores more attractive to local shoppers by decreasing congestion along the old route.

Highways influence land use patterns and property values. Near very small towns, they may alter the overall pattern of development; in larger cities, their effects are primarily on the value of adjacent land. Thus, the impact of highway relocations and bypasses depends on the character and size of nearby towns.

I-A-50.

Mueller, E., A. Wicken, and M. Wood. *Location Decisions and Industrial Mobility in Michigan*, University of Michigan, Institute for Social Research, 1961.

Summary

The study explores the interaction of industrial attitudes and location decisions (new locations, plant expansion, and relocation) among Michigan manufacturers in 1961. The objective was to assess Michigan's attractiveness for industry as measured by satisfaction or dissatisfaction with specific area characteristics. Transportation was a significant, but not a dominant, determinant of plant location.

Study Area

From 1950 to 1960, Michigan had a relatively high unemployment rate and the state government experienced fiscal problems, particularly as a result of decentralization of the automotive industry then taking place. The subject study was an effort to determine whether Michigan's attractiveness for industrial location had deteriorated relative to other states.

Results

The two most frequently cited minimum requirements for plant location were adequate water supply and skilled labor availability.

When asked to select five locational factors from a list of 21 possible responses, manufacturers representing at least half of all employment in the industries covered chose in order: labor costs (wages and productivity); proximity to markets (including transportation costs); availability of labor (skills and supply); industrial climate (attitude of state and community toward industry); taxes; and proximity to materials (including transportation costs). "Traffic access and parking" as an explicit locational factor received a much lower rating (3 to 6%) from industry representatives.

"Transportation facilities" was one of four advantages more frequently mentioned for existing industrial plant locations in Michigan, (cited even more frequently in the Detroit area).

There was no wide variation in the relative importance of locational factors by industrial group type, size of firm (by number of plants) or extent of market (local or national).

Methodology

The study was based on personal interviews with top executives in 239 Michigan and 57 Ohio manufacturing plants in 1961. The sampling was designed to be representative of all manufacturing plants in Michigan. Ohio sampling was limited to three metropolitan areas (Toledo, Cleveland, and Columbus). The study was comparable to an industrial survey completed in 1950.

1-A-55.

Pennsylvania State University, Blairsville: A Bypass Study - The Economic and Social Impact of a Highway, University Park, Pennsylvania, 1962.

Summary

Cross-sectional and longitudinal analyses of socio-economic change in the community of Blairsville, Pa. are related where possible to the relocation of U. S. Route 22, an open-access highway bypassing the Blairsville Business District. During the study period (1949-1959), changes in land use, economic activity, size and characteristics of the population, and local taxes and expenditures are examined.

Study Area and Investment

An unlimited-access bypass highway was constructed in 1953 around Blairsville, a rural town 35 miles east of Pittsburgh, as part of improvements to U. S. Route 22. The old road was retained as an alternate route through town. The population of Blairsville was 5,000 at the beginning of the study period. Bypass effects were somewhat obscured by the simultaneous completion of a major flood control project in 1953, requiring the relocation of four small nearby communities and a small part of Blairsville. Part of the land adjacent to the new road is topographically unsuitable for development.

Methodology

Data were collected through interviews with a sample of town leaders and citizens. Questionnaires were also mailed to holders of non-residential telephone connections. The area covered by the greater Blairsville telephone directory was defined as the "community of interest" for study purposes. Businesses were surveyed directly through interviews and also by counting the number of non-residential electrical power connections. Overall business volume was measured by average power consumption and employment totals. Whenever possible, the surrounding small communities and the entire region were used as control areas.

Impacts

Analysis of land use changes in Blairsville by acres showed that the greatest increase was in schools and public use (551% from 1950-1959). Vacant land showed a net loss. Commercial and light industrial uses increased a total of 56%, primarily near the new bypass. Residential land use increased by 0.6% along the old route, despite a slightly decreased population over the study period.

The value of taxable real property in Blairsville increased steadily, but this increase was not significantly different from those of surrounding communities. Property values increased at a faster rate along the new bypass route than along the old route or in other sections of the borough. Along the new route of the bypass, the value of buildings per 1,000 square feet of land rose 175% in one segment and 40% in another in the 1950-59 period. For the more densely built, older area there was an average increase of about 25%.

The cost of local government increased steadily in all areas, with the greatest single increase in Blairsville being expenditures for protection of persons and property. However, since the average increases in surrounding communities were generally larger than those in Blairsville, there is little evidence of a relationship between the highway and increased governmental expenditures.

The town's total tax levy, real estate tax, occupations tax, per capita tax, and tax rate in mills all increased more rapidly than for neighboring communities. The real estate tax, the primary source of local taxes, increased by 68% in Blairsville, but only an average of 27% in surrounding communities. The occupations tax increased by 16% over the decade, while in surrounding communities this tax decreased by 67%. The only exception was in assessed valuation, which increased more slowly in Blairsville (45%) than in surrounding communities (52%). While differences in taxation and assessment between Blairsville and the surrounding communities were not statistically significant, it was evident that Blairsville met its increasing expenditures by increasing levies more than its neighboring towns.

The total number of businesses in Blairsville declined during the study period (4%) and losses were mainly in manufacturing, construction, and retail business. Service and miscellaneous business increased, and wholesale and transportation business remained the same. Development of business near the bypass was slow, with only 10 establishments by the end of the decade (8 of these were highway-oriented).

The bypass alleviated part of the congestion along the old route, causing a 5% decrease in Average Daily Traffic in 1954 along the most heavily traveled segment of the road. However, by 1959 traffic volume on the old route was above the pre-bypass volumes.

Population decreased by 1.4% (from 5,000 to 4,930) over the study period, but this was not apparently related to the bypass. Out-migration was mainly among teen-age and young adult age groups, while in-migrants consisted largely of professional people (2.5%) with higher education and higher median income levels.

Conclusions

The authors conclude that the negative bypass impacts anticipated before construction did not occur and that highway development is not inherently either good or bad for a community.

I-A-59.

Real Estate Research Corporation, Highway Networks as a Factor in the Selection of Commercial and Industrial Locations, prepared for the U. S. Bureau of Public Roads, 1958.

Summary

An attempt was made to determine the importance of highways in corporate location decisions through a survey of 134 newly located businesses in the Chicago, Pittsburgh, and Hartford Metropolitan Areas during the 1950's. Responses indicated that highway-related factors were seldom dominant in location decisions. The importance of highway factors varies widely for different types of industry.

Study Area and Investment

The three cities selected for study vary in size, age, and topography. Chicago has approximately 4,000,000 residents within the city limits; is relatively flat topographically; and its highways are mainly in regular east-west or north-south patterns, often on city section lines. Hartford has a city population of approximately 175,000 in a valley bordered by the Connecticut River. Major highway thoroughfares are meandering routes due to the hilly terrain, and bridges are numerous. Pittsburgh has a city population of slightly less than 700,000, and the area is largely shaped by the steel industry. Highway routes are irregular due to steep grades; tunnels are common.

The economic activities of each area also vary, but this seems to have had little bearing on highway development: all areas have extensive highway networks.

Methodology

In each metropolitan area, a sample of newly located firms was selected, and a top official in each was interviewed personally. Each of the individuals interviewed was either responsible for the ultimate location decision or well-informed of the procedure followed and governing factors resulting in the decision. Industry types included retail goods and services, wholesale and distribution, manufacturing and processing, and other service industries. The questions were designed to provide information not only on the importance of exposure and access to specific highways, but also on the importance of the available highway network as a whole.

Classification of location criteria included: (1) factors related to a specific highway (highway access, highway exposure); (2) factors related to highway networks (transportation of materials by automotive vehicle, relation of highway network to market and to labor force); and (3) factors not directly related to highways (e.g., non-automotive transportation of materials).

Impacts

Survey results show that highway access and highway exposure are significant in the selection of locations for retail facilities, but not in the selection of new locations for manufacturing. Highway access was indicated as a dominant criterion by 18 of 41 retail establishments; however, only three of 79 manufacturing and distribution firms interviewed considered highway factors critical.

The firms where highway access was the dominant factor were all located in Pittsburgh, perhaps because the rugged terrain and frequent use of center dividing strips on highways make access a more critical problem in Pittsburgh than elsewhere.

Transportation and labor force were cited as dominant criteria by 19 of 79 manufacturing and distribution firms. Labor force accessibility was not a significant factor in location of retail establishments.

Establishments seeking rental quarters were influenced more often by site availability than firms purchasing space. Thirty percent of enterprises renting space listed availability as the dominant factor in their location decision compared to only eleven percent for businesses owning their new premises.

Conclusions

New locations by commercial and industrial enterprises are governed by functional considerations. The primary function of each business determines optimum location, subject to cost limitations. For most commercial and industrial functions, a site near a major highway is more desirable than an equivalent site not so located. However, businesses will not pay a premium or sacrifice other elements of desirability in order to gain a highway site. More than half of the enterprises surveyed were "indifferent" to highway frontage, meaning that they would not sacrifice other considerations to obtain such frontage.

Most firms are dependent to some degree on the existing network of highways. This dependence, however, frequently was not perceived by respondents, who took the existing network for granted.

I-D-15.

Real Estate Research Corporation, *A Study of the Impact of Major Highways on Local Tax Bases*, prepared for the U.S. Department of Commerce, Bureau of Public Roads, 1960.

Summary

The effect of multi-lane, limited access highways on assessment, zoning and taxing practices in Cook County, Ill. and Frederick County, Md. were examined from approximately 1950 to 1960. These data, together with information provided from a questionnaire survey of assessing officials across the country, suggest that highways enlarge the tax base of larger metropolitan areas (provided undeveloped land is available) to a greater extent than for small cities; that taxing jurisdictions in the western and southern regions of the country benefit more by highways; and that special purpose highways have limited impact on the local tax base of jurisdictions they traverse.

Study Area and Investment

Cook County, Ill., an area of about 1,000 square miles, had a 1950 population of about 4.5 million, located mainly in the Chicago metropolitan area. The area has a highly diversified economic base, partly due to its advantageous location for all forms of domestic transport. The area is served by a variety of limited-access highways (both free and toll). The study site consisted of 16.54 square miles adjacent to the Edens Expressway; a 14.65 square mile area in the northwest suburban area was used as control.

Frederick County, Md., an area of about 650 square miles 45 miles northwest of Washington, D. C., is predominately rural and had a 1950 population of 62,000. Two interurban highways serve the area: U.S. 40, east of Frederick, the principal city in the county; and U.S. 240 (Interstate 70-A), extending from a bypass to arterial connections in Bethesda, Md. and Washington, D. C. suburbs. U.S. 40 has roadside access while U.S. 240 is a limited access highway. The specific study site consisted of 26 "election districts" in Frederick County.

Methodology

1959 assessment data was available for the Cook County study area. Population and housing data were obtained from 1950-1959, and zoning ordinances reviewed from 1940-1958.

Data on geography, economy, population and employment, housing, zoning and assessment practices, and traffic counts on major roads were examined for the 26 districts comprising the Frederick County study area.

About 100 questionnaires were mailed to assessing officials in all regions of the U.S.; about 50 usable responses were received. Information was obtained on taxable property removed from assessment by highway construction, and amount and extent of increases in assessed valuation due to highway improvements.

Impacts

Cook County

From 1947 to 1958, the total valuation of real property under the jurisdiction of the Cook County Assessor increased by about 34%. Land rose only 7%, while assessed valuation of buildings rose 49%. About two-thirds of the increase occurred in towns outside the City of Chicago. For the county outside of the City of Chicago, assessed valuations increased by 105%, mostly due to new construction.

The study area showed increases in assessed valuation of about 150% from 1947 to 1959; the rise in the control area was 170%. Land valuation increased 22% in the study area and 18% in the control area; assessed valuation of buildings increased 230% and 250%, respectively. The principal factor underlying these increases, conversion of land to urban uses, was greater in the control area. This is attributed to better access by rail commuter service and greater availability of land suitable for urban development in the control area. Also the proximity of the control area to O'Hare Field and the location of a southwestern portion of the control area within the Chicago Base Rate Area (offering lower rail and truck rates) tended to favor development in the control area over the study area.

Frederick County

Prior to 1950, Frederick County was experiencing net out-migration and was considered economically depressed. However, by 1953 Fort Detrick was in operation, U.S. 240 was completed, and U.S. 40 was extended into the County from Baltimore. Commercial facilities and new housing were developed along U.S. 40. U.S. 240 had little effect on economic growth because of its widely separated access points.

The taking of private property for highway purposes removed an amount of taxable land, but this was offset by general economic improvement, in part due to the highway improvements. The limited access highway did not enhance tax value of rural land, except near interchanges (if local zoning permitted). Highway improvements primarily serve urban terminal points and their greatest economic effect is through enhancement of the economy of primary urban concentrations linked by the highway.

Other Regions (U.S.)

The results of the survey of assessing officials in other regions of the U.S., combined with the data from the above studies, indicated that: (1) highway effects on the tax base are directly related to the size of the city -- larger cities benefit more than smaller communities, provided adequate undeveloped land is available; (2) taxing jurisdictions in the western and southern regions of the U.S. benefit more than in north central or northeastern areas, primarily because smaller population densities lead to greater dependence on automobile transportation; (3) special purpose highways are of limited value to a local tax jurisdiction unless they serve important terminal points within the jurisdiction.

I-A-63.

Smith, Wilbur & Associates, *Maryland Capital Beltway Impact Study: Final Report, Washington SMSA and Maryland Counties* for Maryland State Roads Commission, June 1968.

Summary

The study analyzes the impact of the Capital Beltway on the Washington SMSA in the areas of: economic base; industry; recreation; institutional development; work trips; business centers; residential property values; population allocation; employment; retail sales; labor force, housing units and automobiles; traffic noise; and traffic. While the study area includes the entire Washington SMSA, main emphasis is given to the Maryland Counties of Montgomery and Prince Georges. A variety of methodologies is used to trace the impacts from the opening of the beltway in 1964 to the completion of the study in 1968. Historical trends are analyzed from 1950 to provide a base for assessing impacts.

Study Area and Investment

Four types of study areas are chosen for analysis, two of which are regional in nature and two are detailed. The primary regional area includes the Maryland Counties of Montgomery and Prince Georges. In addition, the entire SMSA region is included for comparative purposes. The two types of detailed study areas are route segments and interchange areas.

Impacts

The study found that, largely as the result of early planning, the beltway fit well into the community. The beltway contributed to the faster growth of the Maryland suburbs in terms of population, private and public employment, and retail trade (at the expense of other regions). The beltway facilitated the relocation of distributional industries to the suburbs as the economy of the SMSA expanded. Use of recreational facilities increased chiefly because of the beltway bridges which provided Potomac crossings convenient for Virginia users. The beltway contributed to expansion of federal installations in Maryland and the attraction of Virginia workers to Maryland. The impact of the beltway on business center is dependent on the size of the center, its proximity to the beltway, the length of trips to the center and the degree of dispersion of the center's trade area. Projections to 1976 indicate little impact on population allocation except in a few specific locations where apartment construction will increase relative to the rest of the region. The two principal impacts of the beltway on traffic have been in the welding of suburban communities of the Washington SMSA into a more cohesive whole and in the provision of a bypass for through traffic.

Methodology

Time series data on population, employment, land use, accessibility, income, utilities and other variables were tabulated by traffic zone. For population, 89 districts, comprising the Washington SMSA, were delineated along the boundaries of 264 traffic zones. The traffic zones followed census tracts, where feasible and were linked through centroids to a coded network of major streets and highways. Other data were custom collected by interview and field assists.

Conclusion

The impact of a highway on land use is conditioned by the degree of "uniqueness" of the highway in the network. The accessibility index is an excellent measure of uniqueness. The impact of highways on land use depends on factors such as the availability of land, the location of the highway with respect to urban expansion, the nature of the local economy, and the characteristics of local communities. Evidence is presented to indicate that the net effect of highways on the tax base will be enlargement of the tax base and improvement in the revenue position of taxing jurisdictions.

I-A-65.

Stroup, Robert H. and L. A. Vargha, "Economic Impact of Secondary Road Improvements," Highway Research Record, Number 16, pp. 1-13, 1963.

Summary

The economic impact of rural road improvements in a six-county area of Kentucky is described and analyzed. The study suggests that construction of all-weather, hard surface roads leads to market adjustments, specialization of enterprise, and concentration of business.

Study Area and Investment

A six-county area in northeastern Kentucky with hill and bottom farming, much of it the subsistence type, was selected for study. Topography was a major determinant of settlement patterns, transportation, and community association. The area was losing population but had an increasing per capita income over the study period (1950-1960). Retail market boundaries in the area were fluid; dominant and subordinate trade centers were in the process of being determined.

Improvements in rural road networks rather than single isolated changes were studied. These consisted of surfacing of intercounty connector and feeder roads. About 400 miles of hard-surfaced roads existed in 1950; mileage increased 120% by 1960.

Methodology

Interviews covering all business operating in the six counties in 1960 were conducted to determine succession of business, changes in merchandise lines, and changes in open-country business location. All business that had failed in the 11-year period (1950-1960 inclusive) was also interviewed.

The relation of changes in retail business dispersion to proportion of farms on all-weather roads was tested by multiple regression analysis. Census of agriculture, of population, and county income estimates were used.

Interviews were also conducted with about 10% of farm operators. The sample was stratified by location with regard to major trade centers, county of residence, and physiographic (four types) locations.

Impacts

Larger trade centers increased during the decade in number of businesses; small (under 20 businesses) trade centers remained static; open-country locations decreased in number. The greatest increases in larger centers and greatest decline in open-country businesses occurred during the period (1955-1960) of greatest activity in road improvement; however, a causal connection between these events was not established.

Of the ten types of businesses increasing most in number, three were highway oriented (restaurants, gasoline stations, motels). Fastest growth was shown by specialty shops.

Multiple regression analysis showed that geographic dispersion of retail business was related to population density, per capita income, and proportion of farms on all-weather roads; the last variable was the most important. This result lends support to the hypothesis that road improvements can have significant effects on market relationships and lead to specialization of enterprises and concentration of business.

I-A-67.

Wheat, L. F., "Effect of Modern Highways on Urban Manufacturing Growth," Highway Research Record, Number 277, pp. 9-24, 1969.

Summary

Manufacturing growth rates from 1958 to 1963 are compared for two groups of cities, an experimental group located on Interstate System freeways and a control group located elsewhere. The two groups were comparable in all major aspects--population, location, air service, economic activity, etc.--except highways. Nationwide, there was no significant difference in the growth performance of the two groups. In areas with dense population and uneven terrain--the Northeast, Southeast, East Midwest, and Far West--freeway cities grew much faster.

Study Area, Investment, and Methodology

The study areas included 106 city pairs (212 cities), mostly between 10,000 and 50,000 in population and located in 40 states. They were selected by screening out suburbs, satellites and other cities over 5,000 in population whose proximity to nearby urban areas might influence their own industrial "pull." The remaining cities were matched, based on factors such as geographic location, population, and economic base, so that each pair had highly similar characteristics.

A pair consisted of a city within eight miles of Interstate System exists (designated a "freeway" city), and another at least fifteen miles from a freeway (designated a control city). A city's growth was defined as its per capita manufacturing employment increase between 1958 and 1963. Growth data for all 212 cities were collected from the Census of Manufacturers.

Impacts

Superior highway facilities can be an important stimulus to manufacturing growth under a certain set of conditions. Although there was no significant difference in growth rates for the two types of cities nationwide, freeway cities did grow faster in regions with dense populations and uneven terrain. In the Southeast, East Midwest, and Pacific Northwest, for example, freeway cities outgrew the non-freeway cities by a 43 to 23 margin, significant at the 0.04 level statistically. In the same regions and including the Northeast, freeway cities above 16,000 in population outgrew their twins 27 out of 31 times. Among pairs with air service in the same group, freeway cities had a 27 to 2 advantage.

On the other hand, non-freeway cities between 16 and 25 miles from the nearest freeway exit did not grow faster relative to their mates than more distant non-freeway cities. The growth-distance relationship was found to approximate a bell-shaped curve with a standard deviation of 5 miles and a peak at zero miles.

Although the two groups were roughly equal in manufacturing, correlations between industry variables and growth was 0.93 for freeway cities but only 0.33 for non-freeway cities. This suggests that freeways affect growth indirectly, as a catalyst in stimulating manufacturing.

Conclusion

Freeways are unimportant in stimulating manufacturing growth unless the region is densely populated with uneven terrain. In such regions, freeways offer relatively substantial time/cost savings. Growth impacts are limited primarily to cities above 16,000 in population, where the industrial base is self-sustaining and capable of expansion. Freeways affect significantly cities through which they pass, their influence on a city diminishing to nearly zero at a distance of about 10 miles.

1-A-70.

Witheford, David K., "Highway Impacts on Downtown and Suburban Shopping," Highway Research Record, Number 187, pp. 15-20, 1967.

Summary

The characteristics of market areas within a fixed travel time from a hypothetical central business district (CBD) and a shopping center are compared before and after highway improvements. For values of travel time coincident with a typical market area boundary for a suburban shopping center, family incomes total more for a suburban shopping center than for the CBD. Highway improvements, increasing uniformly travel speeds in the whole urban area, enhance the relative advantage of the shopping center even though the incremental speed gain is proportionally larger for downtown areas. These relations are examined in Buffalo, New York, using socioeconomic and highway network data from the Niagara Frontier Transportation Study.

Study Area and Investment

The theoretical analysis assumes that residential densities decline regularly with distance from the CBD and that highway travel speeds increase correspondingly. Shopping center trip generation at residential origin zones is assumed to be more sensitive to time than distance, as empirically found. The area enclosed by a fixed travel time radius centered on a suburban shopping center is generally larger than the equivalent area for the CBD. Within the larger suburban area surrounding the shopping center, the resident population not only has greater income per capita, but because of higher levels of car ownership, it also has greater mobility. Thus, even though the population density is lower, the purchasing power within reach of the suburban center(s) may equal or exceed that of the area surrounding the CBD.

Geographic characteristics may also affect adversely the CBD, particularly where the CBD is non-centrally located in the metropolitan area (Boston, Chicago, Cleveland, Memphis, etc.). The actual case examined, Buffalo, New York falls in this category since the CBD is located virtually on a waterfront with development encompassing an angle of only about 200°.

Zone households and income data for Buffalo were arrayed by minutes of travel time from downtown Buffalo and from a suburban shopping center located less than one mile from an interchange of the New York Thruway (toll free for local trips). A 14 minute unrestricted travel time derived from computer-built "trees" of the 1961 highway network (accounting for about 75% of tripmaking to the center and equivalent to at least 20 minutes normal over-the-road and terminal time) was used to define both the shopping center and downtown market areas.

Impacts

Highway improvements reduce travel times and add to the market areas of suburban and CBD centers. However, the increment added to the suburban shopping center is generally much larger than for the CBD. Furthermore, market overlap within the travel time previously defining abutting market areas generally favors the suburban shopping center. The proportion of the original CBD market area now within reach of the shopping center is greater than the proportion of the original market area of the shopping center which becomes accessible to the CBD.

Results from Buffalo, New York illustrate these relations. A 14 minute travel time places most of the downtown area within the market reach of the suburban center but only about 30% of the suburban market area is within the CBD travel radius. Total family income within the 14 minute band is about 25% more for the shopping center than for the CBD. Cumulative number of households with over $5,000 income is 23% higher for the shopping center; for over $8,000 income, it is 77% greater. There are 29% more cars within 14 minutes of the shopping center.

A uniform increase of speed by 4 mph adds a 1-mile wide band to each market area. This addition increases the non-overlapping area income by $68 million for the shopping center and $42 million by the CBD. The added income in the new overlap area is $221 for the shopping center and $206 million for the CBD. The total effect is a relative strengthening of the suburban shopping center.

Conclusions

Highway improvements currently strengthen suburban shopping centers as against the CBD. The tendency for the gap between suburban center and downtown purchasing potentials to widen with highway improvement cannot continue indefinitely; the outer boundaries of urban development are reached by the shopping center before they are reached by the CBD.

The CBD has the benefit of other transport modes (transit) and of shopping by office workers and non-resident visitors. Long term strengthening of the CBD depends on combining measures to improve its relative attractiveness with better access (improved transit).

I-A-71.

Wright, Arthur L. and Melvin G. Blase, "A Depressed Region and Three Myths," Growth and Change: A Journal of Regional Development, Vol. 2, No. 3, pp. 14-22, July 1971.

Summary

Three widely-accepted assumptions underlying planning for economic improvement of depressed regions are challenged. The "myths" discussed are: (1) income is homogeneously distributed in a depressed region; (2) economic improvement will result from linking the region to others with highways; and (3) out-migration is an effective means for improving per capita income. A 44-county area in Missouri (part of the Ozarks Region) provides a case study area for discussing the above assumptions.

Study Area and Investment

The study area is characterized by chronic underemployment, lack of economic opportunity, and low income levels. Agriculture is the largest single employment source, but much land is unsuitable for cultivation. Low farm incomes and lack of employment opportunities in the manufacturing sector have contributed to a high out-migration rate, leaving a population largely old, poorly education, unskilled, and not receptive to change.

A major, four-lane highway artery (Highway 66) has served the area for many years. It was recently improved and changed to an Interstate route (I-44).

Impacts

In 1950, 34 of the 44 Missouri counties had average per capita incomes from $600 to $1,000. In 1960, per capita income ranged from $637 to $1,279. The data indicate that the region is becoming more heterogeneous with respect to income.

The possible impact of Highway 66 was studied by examining per capita income in the eight counties through which it passed with the remaining counties. The 1950 average income was higher in these eight counties. However, it increased less ($803 vs. $997) than in the other counties in the 1950 to 1965 period. No significant change occurred when the highway was transformed to an Interstate route. Discriminant analysis indicates that the main highway had an impact on income originally, but this diminished over time. Intracounty local roads showed a higher and longer lasting correlation with income, indicating that secondary roads may have a more significant impact on the regional economy.

Correlation of income with migration showed that per capita incomes were higher in counties where in-migration occurred, rather than in areas where out-migration took place.

Methodology

The general analytic framework of the study includes: (1) multiple cross-sectional regression analyses for 1955, 1960, and 1965; (2) first-difference regression analyses for 1950 to 1965; and (3) discriminant analysis of data from 1950 to 1965. Regression analyses included twenty-five variables, in addition to per capita income.

I. HIGHWAYS

B. Social and Demographic Impacts

I-B-11.

Ellis, Raymond H. and R. D. Worrall, "Toward Measurement of Community Impact: The Utilization of Longitudinal Travel Data to Define Residential Linkages," Highway Research Record, Number 277, pp. 25-35, 1969.

Summary

An empirical method for measuring residential linkages and linkage patterns is suggested as a basis for quantitatively estimating community consequences of transportation projects. Linkage definition involves analysis of two data sets: the activity patterns of the household, and the set of destination points which the household defines as important. In a case study of 35 households in Skokie, Illinois, travel data over a 26-day period were collected. Destination points defined as important by households were examined by discriminant iterations analysis to insure that the set of linkage definition criteria are uniformly applied for each activity pattern. Results are classified by activity type and principal mode of travel.

Study Area

A longitudinal travel survey of 35 households in Skokie, Illinois included a complete travel diary during a four-week period (in 1965 or 1966) by each household resident.

Methodology

Activity patterns were described by assigning a vector to each destination point. Each vector originated at the homesite and contained elements describing the characteristics of the activity site (e.g. geographic location, type of activity), and characteristics of the household's interaction with the site (e.g. trip rate, mode, travel time). Eight activity categories were used: full-time work; school; religious, part-time work; shopping; recreation; informal socializing; restaurants; community activities and formal socializing. The three principal modes of travel considered were car, public transportation, and walking.

The definition of a set of residential linkages associated with a household is based on a four-step approach: (1) a longitudinal travel survey to identify a complete set of destination points for each household (travel diaries); (2) a household interview to identify the activity sites considered important; (3) a discriminant iterations analysis to identify the criteria underlying the household's choice of important destination points (linkages); and (4) application of discriminant procedures developed in the previous step to the defined activity patterns of other households, thus providing a systematic analytical base.

Discriminant iterations analysis used to define the criteria of households (by removing irrational and random choices) and to generate procedures for defining linkages solely from activity patterns, involved 24 variables including eight dummy variables for the eight activity categories and three for the travel modes, and a set of variables involving frequency, time of occurrence, distance and average speed of trips.

Results and Conclusions

As the authors admit, the discriminant procedures developed to define residential linkages represent the value set of the authors and not the value set of the households. Only 7.5 out of 36.2 destination points visited by the average household during the study period were chosen as linkages. An average of 0.33 trips per day are made to each linkage as compared to only 0.14 daily trips to each destination point. The ratio of linkages to destination points is essentially unity for work, school, and religious, part-time work; about 0.2 for informal socializing; and about 0.1 for all other activity categories. In terms of principal mode of travel, it is unity for walking, 0.55 for public transportation and only 0.11 for automobile.

The success of the analysis must be qualified by the small sample size and its intense geographic concentration. Further tests with larger more spatially diffuse samples of households are desirable. However, the cost of obtaining and coding longitudinal data is prohibitively high (about $5 per household per day). The authors suggest that linkage patterns could be developed from cross-sectional travel data, provided information is available on walking trips.

I-B-50.

Hill, Stuart L., and Bamford Frankland, "Mobility as a Measure of Neighborhood," Highway Research Record, Number 187, pp. 33-42, 1967.

Summary

A "mobility index" is developed and used as a quantitative measure of the impact of highways on community stability and cohesion. Several variables related to housing characteristics of a neighborhood are combined in a single "mobility index" intended to indicate neighborhood socio-cultural stability or cohesion. An index was successfully developed for Beverly Hills, but was less successful elsewhere, primarily because necessary data were difficult to collect. The index is not a normative measure, since high values may reflect adverse rather than beneficial community qualities.

Methodology

No single variable can be used to quantify the often controversial highway impacts on community structure and stability. Accordingly, several variables were aggregated into an index, the mobility index, intended as a measure of community stability. Changes of the mobility index may be used to assess highway impacts on community cohesion.

Selected stability indicators include percent of persons five years or older who occupied the same residences for five or more years; percent of housing units 20 years or older occupied by the same household continuously; percent of single family residence units; and percent owner-occupied units. These quantities are combined linearly to yield the mobility index. High values indicate significant cultural continuity or stability, while low values imply little such stability.

A mobility index was successfully constructed for a test area in Beverly Hills, California. Data problems were encountered elsewhere. Census tract data from which the index was designed to be constructed are available only for communities and neighborhoods within SMSA's. If the index is to be applied to a small urban area outside of an SMSA, data collection costs become prohibitive. Furthermore, census tract boundaries may vary over time. Accordingly, changes of the mobility index cannot be used in a consistent fashion to evaluate highway impacts. Although a simplified index was designed, similar data problems were encountered.

I-B-26.

McLean, Edward L. and William G. Adkins, "Freeway Effects on Residential Mobility in Metropolitan Neighborhoods," Highway Research Record, Number 356, pp. 95-104, 1971.

Summary

The study attempts to delineate metropolitan neighborhoods, investigate the effect of a freeway on residential mobility, analyze freeway-neighborhood relationships, and interpret these findings in a causal and predictive framework. Data were collected for 152 study and 47 control neighborhoods in Austin, Dallas, and Houston, Texas. A "neighborhood" index was formulated to aid in neighborhood delineation and to measure socio-economic level; and a "mobility" index was developed to measure residential mobility. These indexes are reliable measures of the effects of the introduction of a freeway in metropolitan neighborhoods.

Study Area and Investment

Investments are freeways, defined as limited-access highways having four or more lanes and a permanent median divider. The study included four areas in Dallas, one large area in Austin, and five areas in Houston. Significant dates in the analysis were when rights-of-way were authorized, when construction began, and when the freeway was completed. In six study areas these dates were between 1950 and 1960; in four areas they were between 1960 and 1965.

Methodology

Neighborhoods are operationally defined as metropolitan spatial areas that exhibit homogeneous residential housing characteristics based on combinations of city blocks. Neighborhood delineation involved calculating and mapping socioeconomic characteristics for each block (Census of Housing data). The census data were supplemented by field observations to determine basic housing, and economic, transportation and geographic area characteristics, and consultations with individuals and agencies in the communities.

A neighborhood index was developed for 1950 using: (1) proportion of owner-occupied dwelling units; (2) proportion of units in good condition; and (3) proportion of units not crowded. The 1960 neighborhood index included an additional variable (number of rooms per dwelling unit). The formula for the index was an arithmetic summation of these proportions and had a numerical range of 0 to 300.

The mobility index measures residential mobility at five-year intervals (1950-55, 1955-60, 1960-65), and was initially based on city directory information. The index is simply 200-2X where X is the proportion of residents in the same dwelling units, base year compared with five years past.

Neighborhoods, with similar social and economic characteristics to those of the study neighborhoods, not in close proximity to a freeway were used as controls. Neighborhoods were grouped by index level categories and by their spatial relation to freeways. Freeway categories included neighborhoods not bordering the freeway, bordering the freeway, segmented by the freeway, and control neighborhoods. Product-moment and rank-difference correlation coefficients were calculated for each study area and for study and control neighborhoods. Multiple regression analyses were conducted to provide causal and predictive inferences.

Impacts

Neighborhood indexes were generally low, indicating low to intermediate socio-economic levels of housing in most study and control neighborhoods. This distribution may reflect the economics of freeway right-of-way decision, since it usually costs less if a freeway is located in a lower socio-economic residential area. Neighborhoods with low 1950 indexes tended to show increases from 1950 to 1960; those with intermediate or high 1950 indexes showed general declines from 1950 to 1960; and neighborhoods segmented by a freeway were more likely to show a decline.

The general pattern of the mobility index was one of a decline in mobility, except for freeway-segmented neighborhoods where residential mobility was more likely to increase.

Statistical analyses supported the neighborhood delineation methodology. Multiple regression analyses indicated that bordered and not bordered neighborhood categories were not significant independent variables (with a probability of greater than 50 percent). The segmented neighborhood category is a significant independent variable. Residential mobility is likely to increase significantly for a segmented neighborhood. Conversion of single dwelling units to apartments or addition of new multiple-dwelling units is also likely to take place in segmented neighborhoods.

I. HIGHWAYS

C. Land Use and Land Value

I-C-01.

Adkins, William G., "Land Value Impacts of Expressways in Dallas, Houston, and San Antonio, Texas," Highway Research Board, Bulletin 227, pp. 50-65, 1959.

Summary

A review of the findings and methodologies of three economic impact studies dealing with land values as influenced by expressways from 1945 to 1957 in Houston (Gulf Freeway), Dallas (North Central Expressway) and San Antonio (Expressway). The analyses are based on real estate sales and utilize before/after and control area comparisons. Each case study is summarized and data requirements and measurement techniques are specified. It is suggested that land values are the best single indicator of economic impact since nearly all effects of highways are eventually reflected in land values.

Study Area and Investment

Each city studied had a growing population during 1930-1957. Houston and Dallas have an industrial base while San Antonio is mostly dependent on agriculture, military, medical services and tourism. Each expressway studied was the first limited-access facility in the city and was a radial highway routed through older areas of low-cost, middle-class dwellings, retail and commercial establishments and manufacturing. The Houston and Dallas expressways had continuous frontage roads; the San Antonio expressway did not.

Methodology

Each case study analyzed land value using real estate sales data obtained from local sources and differentiated sale price of land and improvements from assessed value. The author points out the incomplete nature of before/after methodology; the difficulty of choosing a truly comparative control area; the difficulty of separating land value from land use; and the need for more precise measurement tools.

The Houston and Dallas studies classified land by location only. The San Antonio study was based on land sales data and classified land by use, zoning, and street location. Generally, the study areas were bands averaging about a half-mile in width on either side of each expressway and about 3 to 6 miles in length.

Data sources were County records. In some instances, these were supplemented by interviews. The general approach was a "before" and "after" comparison combined with comparisons with control areas.

Impacts

Land adjacent to the expressways in Houston and Dallas experienced significantly greater increases in value than land in control areas. However, the smallest increases in value occurred for land near, but not adjacent to, the expressway. For example, the Dallas study showed that unimproved land abutting the expressway increased in constant dollars by 270% from 1946-1951 (the "before" period) to 1952-1960 (the "after" period); nonabutting, unimproved land increased in value by only 17%.

Open land traversed by the Dallas highway was developed in the "after" period, but at a relatively slow rate; residential subdivisions accounted for 13% and industrial development for 7% (the remaining land being in agricultural use or idle) in 1959, i.e., seven years after completion of the expressway. Land development in control areas was negligible over the same period.

The Dallas study also included a small town (Richardson, Texas) whose accessibility to the Central Business District (CBD) of Dallas was greatly improved by the expressway. Richardson experienced an upsurge of population growth coincident with completion of the expressway. However, the rate of population growth of one control town (Mesquite) was equally great, though the rates of three other control towns were much smaller.

The value of unimproved land in Richardson was about half that of comparable land in Dallas in the "before" period. In the "after" period, unimproved land in Richardson and Dallas had about equal value.

The San Antonio study, which classified land by use, zoning, and street location, yielded somewhat more detailed results. The overall net influence of the two expressway sections in San Antonio was estimated at about 130% increase over land prices in 1941-1945, the "before" period. Net influence is the excess in price increases over control areas and is for land only (i.e., after adjustment to remove value of improvements).

Land abutting frontage roads and access ramps was enhanced about 400%. Properties otherwise abutting the expressway right of way had net benefits of 300%. Properties on main thoroughfares within three blocks of the expressway, but not abutting it, gained 115%. Land on minor streets, the most frequent type of location, increased 30%.

Land use and zoning were important in determining the net increases given above. Properties used for single family dwellings showed, on average, an insignificant change (over control areas). One-family dwellings were, in fact, the only class of properties showing some evidence of expressway damages. Land for apartments increased 110%. Land for non-residential uses increased 330%; vacant land 310%.

I-C-02.

Adkins, William G., James E. Frierson, and Russell H. Thompson, Farm Land Values and Rural Road Service in Ellis County, Texas 1955-58, Texas Transportation Institute, A. & M. College of Texas, College Station, Texas, June 1960.

Summary

Relations between farm land values and quality of road service in Ellis County, Texas are analyzed from data on 214 farms sold during 1955-1958. Buyers' estimates of road effects on land values were also obtained. Analyses were conducted on land price, value of road type location, correlation of land use and road type, and buyer characteristics. It was found that land on paved roads was likely to be valued at a premium over land on gravel roads; locations on gravel roads were in turn more valuable than locations on dirt roads. The only strong relation between quality of road service and land use was in terms of the value of buildings on the land. On average, land on gravel and paved roads had buildings valued more than five times those on land serviced by dirt roads.

Study Area and Investment

Ellis County is a predominantly agricultural area of about 1,000 square miles, bordered on the north by the Dallas and Fort Worth metropolitan area. The 1950 population was 45,645; 58.3% was rural (compared to a statewide rural population of 37.3%). In 1960 cotton was the county's most important agricultural commodity; grain, sorghum, corn, and beef cattle were growing in importance. About 73% of farms in Ellis County were in cropland in 1954, compared to 25% for the state.

In 1950, 27% of Ellis County farms were located on paved roads; 44% on gravel roads; and 29% on dirt roads.

Methodology

During the study period (1955-1958), more than 500 transfers of acreage tracts occurred in Ellis County. Price information and legal descriptors were obtained for 394 of these; complete sales and farm size data were obtained for 214. Road service characteristics were defined by road type: dirt; gravel; farm-to-market (state built roads with 20 feet of treated surface); and other state highways. Distance of farms to paved roads was also determined.

Many factors influence market price of farm land. Cross classification and multiple regression analyses were attempted, the latter technique proving the most efficient. More than 30 variables were considered in attempts to isolate road service effects on land values. The two most significant factors (besides roads) influencing value of land were land use (expressed in terms of value of buildings on the land) and productivity (expressed in terms of percent cropland, yield, and land and soil classifications). In comparative analyses, these two variables, in addition to road type location, were taken into account.

Data sources included warranty deed records, interviews with buyers, and maps of the area.

Impacts

Initial analysis of land prices and road type location showed that average price per acre was $97 for farms on dirt roads; $138 on gravel roads; $150 on farm-to-market roads; and $168 on other state highways. The average for all farms was $136 per acre. When relations to land use and productivity were included, similar consistent differences were found. For example, there was a 74% increase between location on dirt roads and location on state highways, essentially the same as the difference noted above.

The prices of land located on dirt and gravel roads were not greatly affected by distance from pavement. With other important variables held constant, most of the discount in price for location on dirt roads occurred within the first mile (from a paved road); larger distances had a relatively slight additional effect.

Several buyer characteristics were correlated with road type. In 1959, only 14% of buyers of farms on dirt roads lived on the land purchased; about two-thirds of these buyers indicated that their purpose in buying the land was to add to adjacent holdings. Thirty percent of buyers of farms on gravel roads and thirty-six percent for farms on paved roads lived on the purchased land.

The only significant correlation between quality of road service and land use was in regard to value of farm buildings: land on gravel and paved roads had buildings valued more than five times those on land serviced by dirt roads. Only one-third of farms on dirt roads had dwellings. Apparently, farms on dirt roads are accorded little value for residential purposes. Generally, the better the road type, the greater the building value per acre.

I-C-08.

Carroll, Donald D., J. R. Borchert, J. Schwinder, and P. M. Raup. The Economic Impact of Highway Development Upon Land Use and Value: Development of Methodology and Analysis of Selected Highway Segments in Minnesota, University of Minnesota, September 1958.

Summary

The study examines the process and causes of change in land use and value, and methods for analyzing growth patterns spatially and over time. The study focuses on three highway segments in the Minneapolis area from 1950 to 1958, including a bypass highway, a feeder into the city, and a limited-access divided highway. Emphasis is on methodology, with implications for further use in impact analysis.

Study Area and Investment

The three highway segments were chosen to represent different road types and to reflect various levels of rural, urban, and suburban development. Their locations reflect differing growth patterns of the Twin Cities area.

Impacts

Land use patterns for 1950-58 established through aerial maps indicate that commercial-industrial use on highway frontage doubled over five to six years and that roads introduce a strong tendency towards commercial-industrial strips in suburban areas, regardless of zoning. The pressure for commercial development caused by a highway in a residential area soon arrests residential growth. In urban-fringe areas, commercial-industrial land use is related to the density of local and commuter traffic. Furthermore, commercial-industrial development is attracted to interchanges, rather than interior locations, by a three to one ratio.

Land values increased progressively as land use, stimulated by highway construction, changed from agricultural to a combination of agricultural, residential, commercial and vacant land. Later changes were dependent upon the area's rate of urbanization, and were largely independent of the highway.

Methodology

Time series mapping and land use profiles of selected land strips were used to determine urban growth trends since 1900. Land values were derived from annual assessors' data and property sales statistics through regression analyses and frequency distributions. Areas were divided into grids in order to make land use and value data comparable.

Conclusions

A major theme of the report is that economic development stimulated by highways in turn affects further highway development. Land use and land values are not related simply to highways; often, they are independent of highways. Accordingly, isolation of independent urban growth trends over time is essential in assessing land use impacts of highways. The time sequence of land use and value changes is of major importance in identifying causal links in land development.

I-C-11.

Cribbins, P. D., W. T. Hill and H. O. Seagraves, "Economic Impact of Selected Sections of Interstate Routes on Land Value and Use," Highway Research Record, Number 75, pp. 1-31, 1965.

Summary

The economic effects of controlled-access facilities in North Carolina on surrounding property values and development are assessed using a before and after method and multiple regression analysis techniques for each study period. Three sections of Interstate Routes I-95, I-40, and I-85 in three counties are examined. These roads are radial-interurban highway segments in rural-urban fringe areas. Land values were examined as a function of: parcel size; year of sale; vacant/non-vacant land use; rural-urban land use; subdivision; roadside location (with respect to test facility); alternate roadway location (with respect to other major routes); and three location variables (straight-line distance to the central business district; to the right-of-way; and to the nearest interchange).

Study Area and Investment

In 1960, 200 miles of controlled-access Interstate highways had been completed in North Carolina. The three segments chosen for analysis (radial highways in rural-urban fringe areas) satisfied the condition that public notice of highway construction had been given at least three years prior to 1960, and offered the following advantages for study: clear separation of highway impact from city influence since distance from radial facility and the CBD were independently variable; easy tracing of land use changes since these rural-urban fringe areas were mostly undeveloped.

Impacts

A controlled-access roadway does not appear to disrupt overall property values in the general area in which the roadway is constructed. The average price of all land was significantly higher in the after period as compared to the before period, with one exception. The magnitudes and percentages of increases varied greatly between sites and between land uses. The largest increases were observed for farm land (198.2%) and rural residential land (197.2%) in one of the subject counties.

The most important single factor influencing land value for all land-use types was size of parcel. For all sites and uses, smaller parcels were sold in the after period. Decreased parcel size may not be a direct highway effect but rather a result of demands of an increasing population on a fixed land supply. The causation chain was not clear, since the magnitude of change in parcel size was erratic.

Statistical analysis indicated that the investigated highways had no measurable effect on development within the study area. The absence of clearly discernible patterns between land use or land values and highway variables suggests that general increases in land value are determined largely by conditions within the localities, and are influenced only indirectly by highway facilities.

Methodology

Before and after analysis was conducted in an overall study period from January 1, 1947 to June 30, 1961. Data bases included: tax maps and records, warranty deeds, airphotos, and field checks to determine land use. Multiple regression analysis was performed to relate land values to ten variables (parcel size, year of sale, vacant/non-vacant, rural-urban, subdivision, roadside, other roadway, distance to right-of-way, distance to CBD, distance to interchange). Results of preliminary analyses indicated that the land use variables (vacant/non-vacant, rural-urban) were highly significant factors in sales price. Accordingly, a second analysis was performed using seven land classifications: vacant, farm land, residential, public, commercial, industrial, and rural-residential.

I-C-29.

Kentucky, University of, The Effect of the Louisville Watterson Expressway on Land Use and Land Values, Lexington, Kentucky, 1960.

Summary

The effects of the Louisville Watterson Expressway on land use and land value were assessed, using three time periods (pre-construction, during construction, and post-construction) and control area comparisons where possible. The expressway, a four-lane, limited access facility bordering Louisville on the south, was opened in 1956.

Study Area and Investment

Louisville's main employment base is manufacturing, totaling 35.7% of the labor force. The area is served by railroads, bus lines, and two major airports; low cost water transportation has been a significant factor in determining industrial location. The Ohio River, bordering Louisville on the north, limits the city's expansion in north and west directions. The population of Jefferson County increased 20% from 1950 to 1958; Louisville has also experienced growth, but at a slower rate.

In 1959, the Watterson Expressway was a 12.7 mile, four-lane facility passing through unimproved land on the eastern and western extremities, and through residential land along the middle portion of the road. Commercial developments were located near several intersections with radial streets. An eight-mile portion of the expressway was studied.

Methodology

A land use inventory was conducted using 1947 as the base year, and study areas were defined north (3,695 acres) and south (4,950 acres) of the expressway. A smaller area was also studied within approximately 1,000 feet of the road. Land use classifications included: residential-vacant (land subdivided for residential use, but not yet developed); idle; farm; residential; commercial; industrial; and institutional. Residential building permit data were examined, and interviews were conducted with local real estate agents, commercial developers, and individual business establishments.

Four study areas were selected for analysis of land values, each representing four different property types (commercial, old residential, new residential, and farm land). Control areas were located for commercial and old residential areas, and correlation techniques were used to estimate highway impact for the remaining areas. Three time periods were used: (1) pre-construction (1940-1946); (2) construction (ending in 1950 for new residential and farm land area, in 1952 for the commercial area; and in 1955 for old residential areas); and (3) post-construction (extending through 1958).

Impacts

Examination of land use in 1947, 1954, and 1959 showed that by 1954, the amount of farm land had decreased significantly south of the expressway (from 82% to 57% of total land area). Residential land use increased from 5% to 16% of total land. Residential-vacant land increased (from 4.7% to 9.7%), as did idle (6.3% to 11.2%), industrial (0.9% to 3.1%), and institutional (0.1% to 0.9%). Commercial land showed a slight decline (from 1.9% to 1.6%). Similar, though smaller changes were observed in the area north of the expressway.

From 1954 to 1959 there was a continuing decrease in farm land on both sides of the expressway. Residential land increased, largely through conversion of land from the residential-vacant and idle categories. The initial increase of land in these categories shows that as land moves toward its ultimate use, it is held out (perhaps for speculative reasons) temporarily.

Residential property closer to the expressway tended to be less expensive, while property 1/2 to 1 mile from the road showed value increases because of increased accessibility without highway annoyances. It is hypothesized that builders, anticipating adverse highway impacts, chose to build less expensive housing near the expressway.

Land at interchanges developed more rapidly than did land between interchanges. However the growth pattern was inconsistent, with some interchanges exhibiting no growth. Some adverse expressway effects on local business establishments were observed, but these appeared to be diminishing over time.

The effect of the expressway on the value of old and new nearby residential development was insignificant. Land value increases were most substantial when accompanied by a conversion to a higher land use; especially when farm land was converted to commercial uses. In these cases, value increases directly attributable to the expressway ranged from approximately 100% to 300%. Unconverted farm land showed a slight positive increase (15%).

I-C-32.

Lemly, J. H., "Changes in Land Use and Value Along Atlanta's Expressways," Highway Research Board, Bulletin 227, pp. 1-20, 1959.

Summary

An analysis of changes in land use and value from 1941 to 1956 along a 7.5 mile segment of Atlanta's Northeast Expressway was conducted, using before and after and control area techniques. Changes were evaluated in relation to: distance from the central business district (CBD); distance from the expressway; and accessibility to the expressway. Control areas were located in the southern Atlanta area. Property sales and prices provided the basis for identifying changes during the study period.

Study Area and Investment

The Northeast Expressway feeds traffic into the northern portion of Atlanta's CBD. The expressway studied is the oldest completed section, has eight intersections, two street grade separations, and serves a broad cross-section of commercial and industrial properties as well as suburban residential sectors. The expressway had been under development for eleven years at the time of the study.

Methodology

A fifteen-year study period was divided into three segments: 1941-1946, prior to construction; 1947-1951, planning and initial construction; and 1952-1956, partial expressway completion. It is recognized that an additional post-construction period analysis would provide more conclusive insights. Land value and use were derived from property sales statistics. Three location designations (distance from CBD, distance from expressway, and accessibility to expressway) were used to organize and examine changes during the study period.

Impacts

The relation of land values to distance from the CBD was influenced by a geographical factor. All property on the east side of the study area was closer to the CBD and values were consistently higher than for property on the west side. In Period I (1941-1946), land values did not vary uniformly with distance to the CBD; neighborhood characteristics were important in determining land value. New development showed a tendency to leap-frog over older regions with declining desirability, causing irregular value patterns. In Period III, only two major variations due to neighborhood characteristics were noted. The introduction of the expressway seems to have resulted in a more uniform distribution of values with distance to the CBD.

In Period I, land closest to the expressway had lower value than land farther removed. This was largely a reflection of the fact that the expressway was routed through vacant or underdeveloped land wherever possible. In Period III, this trend still existed, but the discrepancy in values had decreased substantially. The expressway led to an increase in value of adjacent land, and the study suggests that such appreciation will continue.

Significant changes in land values occurred along major streets crossing the expressway. The rate of commercial development along these major traffic arteries (all constructed prior to the expressway) accelerated markedly after expressway construction. The increase is attributed to accessibility to the expressway.

Other expressway impacts included: a rapid change from residential to commercial and light industrial activity in the downtown sector of the study area; and a large conversion of land to industrial zoning or use near the expressway; and new residential development beyond the study area.

Conclusions

The expressway had a major influence on land use and land value. These impacts are likely to be found generally in other metropolitan areas.

I-C-43.

Philbrick, Allen K., Analyses of the Geographical Patterns of Gross Land Uses and Changes in Numbers of Structures in Relation to Major Highways in the Lower Half of the Lower Peninsula of Michigan, Michigan State University, 1961.

Summary

The expansion of urban land uses and structures was related to the pattern of highway development in the Lower Peninsula area of Michigan by comparative mapping techniques. Gross land use changes over time were evaluated, and urban land uses correlated with distance from highways and distance from urban centers. Farm and non-farm dwelling units were also examined by mapping techniques. Ten dispersed city regions were identified and spatially related to a "web of highway impact" area.

Study Area and Investment

Gross land use was examined in 47 counties with a total land area of about 29,000 square miles and a 1950 population of 5.8 million; structures (farm and non-farm units) were examined in 28 of these counties. State and federal highways totaled 5,457 miles in the entire study area. The investments studied were mainly grid or radial highways.

Methodology

The land use study included: classification of land uses (agriculture, forest, non-farm residential, and other non-farm uses); mapping (based on observations by traversing the area by automobile and from previous records); map analysis; and interpretation. Structures on the land were classified as: (1) farm residences; (2) non-farm dwellings; and (3) stores or small business establishments. Land was classified by "quarter sections," i.e., unit areas of 1/4 square mile.

Data, from regional planning commissions and the state highway department, were compared from the late 1930's to the 1950's to evaluate structure development.

The overall study area was divided into "cells" bounded by intersecting state and federal highways. There were 254 such cells in the entire area. Each cell was divided in turn into "strips" parallel to each highway; strips had a depth of 1 mile (composed of two rows of quarter sections) and lengths varying from 3 to 9 miles (average length for all strips was 6 miles). Mapping by strips was used to examine the variation in non-farm land use with distance from highway frontage and distance outward from urban centers.

Each cell was characterized by the average percentage of its quarter sections exhibiting some land use other than agricultural or forest. Each strip in a cell was similarly characterized by its percentage of quarter sections having some non-farm use. Strips having percentages higher than the average for their cell were considered to show impact by highways. All impacted strips which formed a compact group contiguous to one of the highway frontages were shaded on a map to display the "web of highway impact."

Impacts

About 93% (5,100 miles out of a total of 5,460 miles) of state and federal highways in the study area showed impact to a depth of at least one mile. The percentage of impacted areas contiguous to highway frontage was somewhat lower. About 82% (8,960 miles out of a total frontage of 10,900 miles) showed impact to a depth of at least one mile.

The proportion of miles of highway (both sides) exhibiting impact two or more miles in depth (significant because it describes more than the usual roadside clutter of houses and highway-oriented businesses) was 76%; and for three or more miles the percentage was 38%.

Analysis of the composite results showed that the "web of highway impact" area (i.e., the area occupied by contiguous strips having greater than average non-farm land use) was 43%. At the same time, 74% of all quarter sections having non-farm residences or businesses within them were within the "web of highway impact" area. This result suggests that the "web of highway impact" is a measure of the geographic distribution of a dispersed urban area whose connecting links are state and federal highways.

Ten "dispersed city" regions were identified within the study area using the "web of highway impact' as a measure and visual analysis. The ten dispersed city regions occupied about 26% of the total study area in 1950 and were geographically grouped in three major complexes (Detroit-Saginaw, Western Michigan, Capitol Complex). About 82% of the population of the overall area lived within these dispersed cities in 1950. The percentage of population living within nucleated settlements (incorporated or unincorporated) in each dispersed city region varied from 22 to 53%. Almost 90% of the total population increase of the study area from 1940 to 1950 was within the dispersed city regions.

Structures (farm and non-farm) were examined in relation to highways for 28 counties within the study area. Their total population in 1950 was 5.1 million of which 1.16 million was rural. The proportion of rural population living in non-farm dwellings increased from 3.6% in 1940 to 14.6% in 1950. About 74% of units constructed during the decade were within the "web of highway impact" area. The high increase of non-farm dwellings, substantially highway-oriented, underscores the dispersion of urban land uses and urban population after World War II.

Conclusions

The observed patterns of urban facilities illustrate the growth of dispersed city regions of much larger area than previously supposed. Dispersed city regions are inter-connected by highways into what is called the "dispersed city realm."

I-C-45.

Rogers, Andrei, The Time Lag of Factors Influencing Land Development, (in collaboration with F. S. Chapin, Jr., T. G. Donnelly, and S. F. Weiss), Institute for Research in Social Science, University of North Carolina, Chapel Hill, N.C., October 1963.

Summary

Time lag of primary factors as they act together to structure spatial distribution of urban activities is analyzed. The City of Greensboro, N.C. was the study area. Six key independent variables influencing land development are examined over a 12-year study period (1948-1960). The two most statistically significant independent variables ("accessibility to work areas" and "distance to nearest elementary school") had lag times between 3 and 6 years.

Theories and Assumptions

The land development pattern of a city is the cumulative result of public and private decisions over time. "Primary" decisions consist of preconditioning actions (e.g., location decision for a new highway; extension of water and sewer facilities into an area); "secondary" decisions are triggered by primary decisions. Together, they produce the aggregate land development pattern of an urban area.

Time lag is a continuous phenomenon rather than a discrete time period. However, for purposes of the study, time lag is defined by the elapsed time for a change in a primary factor to achieve its maximum influence in land development. Maximum influence is defined by the maximum of its contribution to the statistical explanation of total variance or by the maximum of its relative influence with respect to predictive ability within the total mix of independent variables.

Methodology

The study area (Greensboro, N.C.) was gridded into 3,980 square cells, 1,000 feet on a side. Six key independent variables were sufficient to represent adequately fundamental factors influencing land development: (1) marginal land not in urban use; (2) assessed value; (3) accessibility to work areas; (4) availability of public sewerage; (5) distance to nearest major street; and (6) distance to nearest elementary school.

A linear regression model was used to relate total land in urban use to the six independent variables. Factors (1) and (2) were held constant at their 1948 level, since data were available only at one point in time. Regression analyses were conducted for the remaining four factors at 3-year intervals.

Results and Conclusions

Regression results indicated that 'accessibility to work areas' reached its peak influence with respect to 1960 land use around 1957; 'distance to major street' and 'distance to nearest available elementary school' reached their peaks around 1954. 'Availability of public sewerage' showed a uniform distribution of influence.

'Accessibility to work areas' and 'distance to nearest elementary school' were the most statistically significant variables -- the former seemed to exhibit an influence after a 3-year time lag, while the latter showed a slightly longer time lag (between 3 and 6 years).

The time lag in newly developing areas was examined by using only cells totally undeveloped in 1948 (2,556 cells). The peak influence point of 'accessibility to work areas' shifted from 1957 to 1948, indicating that the time lag of this factor in outlying newly developed areas is considerably longer than that for the urbanized area as a whole. The other factor, 'distance to nearest available elementary school', still exhibited a 3 to 6 year time lag in newly developing areas.

Examination of residentially developed cells (2,003 cells) increased the time lag of 'accessibility to work areas' from 3 to 6 years, and 'distance to nearest available elementary school' was reduced to less than 3 years.

The significance of these results must be qualified by the relatively narrow range of changes in the independent variables over the 12-year span examined.

I-C-50.

Stein, Martin M., "Highway Interchange Area Development -- Some Recent Findings," Public Roads, Vol 35, No. 11, pp. 241-250, December 1969.

Summary

Data on 332 interchanges, predominantly rural, in sixteen states show that interchange land development is affected both by type of intersecting highway and by the relative accessibility of interchange quadrants. A large part of development consists of highway-oriented businesses (motels, service stations, restaurants). In contrast, interchange development on a circumferential, suburban highway shows rapid growth in numbers of apartment houses, churches, schools, shopping centers and industrial parks.

Previous studies on the relation of interchange development to traffic volumes, distance to urban centers, and population of nearest urban center are summarized. Models and statistical approaches to forecasting of interchange development are also reviewed.

Study Area and Investment

Interchanges in predominantly rural areas are examined from 1960 to 1967. Development is statistically correlated to the kinds of intersecting facilities and the interchange quadrant. Interstate highway interchanges with local roads, state-numbered highways, and U.S.-numbered highways are addressed. Some data are also presented for Interstate-Interstate crossings and for interchanges of two non-Interstate highways.

In the case of an Interstate facility, two quadrant groups are defined. The first quadrant on the motorist's right as he approaches the interchange (on the Interstate highway) from either direction is the 'right' quadrant; the remaining two quadrants comprise the 'other' group. Interchange design is also evaluated, based on accessibility provided by free access or frontage roads.

Interchange development at circumferential highways is discussed, with specific reference to the Capital Beltway in Washington, D. C., Route 495 in Massachusetts, and the Baltimore Beltway in Maryland.

Impacts

For all types of interchanges, agricultural use accounted for 36% and residential use for 23% of all interchange-related land, while 11% was vacant. Highway-related uses accounted for 17% and institutional, industrial, and commercial uses took up the remaining 13% of the land.

A division by type of intersection resulted in significant differences from the average percentages. Interstate highway interchanges with local roads, for example, showed 43% agricultural and/or vacant land, while intersections of two Interstate highways had 55% of land in these categories. The difference is attributed in part to the fact that Interstate-Interstate intersections were the latest to be constructed and have not yet developed fully.

Directional and cloverleaf interchanges were found to have roughly equivalent amounts of commercial, industrial, and institutional land. However, among cloverleaf interchanges, those with access provided by frontage roads or crossroads had significantly more intensive development than restricted access interchanges.

An evaluation of development along suburban circumferential highways revealed a much different developmental pattern. In such cases, industry, commerce, and high-density residential uses appeared much more frequently than highway-related businesses. For example, surveys of Capital Beltway interchanges near Washington, D. C. between 1964 and 1968 showed a continuing increase of institutional uses such as churches and schools, with apartment buildings the second most frequent use of interchange land.

Methodology

Seven land use development categories were used to correlate data on 332 interchanges. These included: highway-related development; commercial; residential; agricultural; vacant; institutional; and industrial. Data was obtained from recently completed interchange studies. Predictive techniques developed in other research efforts are discussed, and include: using ratios to compare different land use development types; multilinear regression analysis; and simultaneous equation modeling. Examination of land development over time indicates that certain land uses attract other uses; dynamic modeling is suggested for analyzing and predicting these relationships.

II. MASS TRANSIT

II-14.

Cannon, Colin A. and Michael J. Dear, The Impact of Rail Rapid Transit Systems on Commercial Office Development. The Case of the Philadelphia-Lindenwold Speedline, University of Pennsylvania, Transportation Studies Center, June 1972.

Summary

A preliminary analysis was made of the effects of the Philadelphia-Lindenwold Speedline on commercial office development in the Philadelphia metropolitan region and the "Speedline Communities" in Camden County within this region. Trends in growth and spatial distribution of population, total employment (disaggregated into manufacturing; finance, insurance, and real estate; wholesale and retail trade; and small services and amusements), and commercial office development (available space, new construction, rent levels) are analyzed in relation to the mass transit facility.

Study Area and Investment

The Speedline is an electric, highly automated, dual rail rapid transit facility, opened in 1969. It links the Philadelphia central business district (CBD) with the city of Lindenwold in Camden County, and passes through several low-density suburban communities in southern New Jersey. The Speedline route is 14.5 miles long; parking facilities are available at six suburban stations for approximately 8,300 cars.

Methodology

Data were collected at the metropolitan (Philadelphia SMSA), county (eight counties within the SMSA), and local (municipalities near the Speedline) levels. The economic and demographic spatial structure was analyzed from population census data and employment by two-digit SIC codes for counties and minor civil divisions. Additional data were building permits and business telephone activity, and interviews with recently located office occupants and local commercial office realtors and developers.

Impacts

Population, economic growth, and commercial office development patterns from 1960-1970 were examined for the Philadelphia SMSA, Camden County, and "Speedline Communities."

The city population of Philadelphia declined at a mean annual rate of 0.3% from 1960-1970, while suburbs in both Pa. and N.J. gained steadily (2.1% and 2.7% per annum respectively). Philadelphia experienced only a small relative expansion in total employment during this period, while the surrounding counties exhibited strong growth.

Camden County showed a similar decentralization trend. Camden City (the largest municipality) declined while the "Speedline Communities" increased both in population and employment. The largest of these communities (excluding Camden City) is Cherry Hill, N.J., accounting for 40.8% of the communities' population in 1970.

Finance, insurance and real estate (FIRE), services and government expanded most rapidly during this period. These groups have traditionally been heavily concentrated in the central core and are the most intensive users of commercial office space. From 1960-1970, two-thirds of the total growth in the SMSA was in suburban areas.

Employment in Camden City fell from 64.6% of the county total to 36.1%, while the suburban municipalities rose correspondingly. Losses in the city were mainly in manufacturing industries. The "Speedline Communities" as a whole experienced growth in *all* examined sectors and also grew more rapidly than the county as a whole in all sectors except small services.

Philadelphia dominates the current stock of office space, but a rapidly growing amount is being supplied in suburban communities. From 1960-1970, two-thirds of the new suburban space was in Montgomery and Camden Counties, concentrated in a few communities, especially those which exhibit agglomeration economies (region-wide accessibility, for example).

The Speedline is expected to have an impact on the Philadelphia CBD as well as on suburban areas (especially Camden County). Office construction activity along the Speedline corridor, and especially in the vicinity of Haddonfield Station, is presently (1972) flourishing. Although vacancy rates are high and rental levels comparable with other suburban locations, there is a steady net absorption of office floorspace in Speedline locations. This is not the case in other suburban locations.

The Speedline has provided an impetus for small, but significant changes in suburban office development. Interviews of post-1968 office space users within Haddonfield Station proximity (43 industries) indicated that 68% of these companies had relocated from Camden City. The relative importance of the Speedline among the factors mentioned in the location decision (dissatisfaction with Camden, desire to expand, access to clients and employee residences, the Speedline) is difficult to assess. However, present trends indicate that the Speedline may be causing spatial displacement of activity, rather than generating new activity. Thus, rather than rejuvenating Camden City, the Speedline has provided an opportunity for firms to leave the city.

The Speedline has reduced significantly automobile traffic congestion between south Jersey and downtown Philadelphia. Ridership on the Speedline doubled from 1969 to 1972 to 32,000 person trips per day. The success of the line in serving low-density areas indicates that residential high-density is not a prerequisite for transit use, as suggested by other research.

A review of transit experiences in Toronto and San Francisco suggest that the precise effects of transit on real estate development are difficult to assess. Residential development (especially construction of high-density apartment buildings along the transportation corridor) tends to be most immediate, followed by construction of office buildings. Generally, the response of real estate developers to transit investment tends to await completion of the facility.

II-19.

Heenan, G. Warren, "The Economic Effect of Rapid Transit on Real Estate Development," The Appraisal Journal, Vol 36, No. 2, pp. 212-224, April 1968.

Summary

The economic effects of public transit are discussed, with specific reference to the Yonge Street Subway in Toronto, opened in 1954. Additional planned and operating mass transit facilities in the Toronto Metropolitan Area, and the planning aspects of the Bay Area Rapid Transit (BART) System in San Francisco are also discussed. Substantial impacts of transit on land use are suggested, especially those arising from housing, manufacturing, and commerce. The author advocates integrated transportation and development planning, and views mass transit as an essential part of a balanced urban transportation system.

Study Area and Investment

In 1954, thirteen municipalities united to form the Municipality of Metropolitan Toronto, and assume responsibility for major regional services, including transportation. The municipality includes an area of 720 square miles, and had a 1968 population of 2,250,000 persons.

The 4 1/2 mile Yonge Street Subway, along Toronto's most heavily traveled route, was opened in 1954. In 1963 an eight mile crosstown extension to this subway was completed (the Bloor-Danforth-University Subway). Additional extensions are planned to enlarge the system to a total of 21 miles.

Impacts

The author suggests that the 4 1/2 mile Yonge Street Subway System is responsible for $10 billion of development near the subway line. Over a decade, property value appreciation has totaled $15 billion; two-thirds of this is attributed to the subway route. From 1952 to 1962, tax assessment increases in districts contiguous to the subway ranged from 45% to 107%, while the remaining city areas averaged a 25% increase.

From 1959 to 1963, 48.5% of all high-rise apartment development occurred in four planning districts through which the subway passes. Also, the bulk of major office construction during the same period occurred in three planning districts serviced by the transit line. Two-thirds of all development was within five minutes walking distance from the subway.

Zoning policies were redefined by Toronto's planning staff to structure and accommodate growth. Apartment zoning includes four locational sectors (central, inner, intermediate, outer). The inner and intermediate sectors are zoned according to three density ranges, based on proximity to the subway.

A 52-mile subway system and rail commuter line operating along the north shore of Lake Ontario was subsidized by the Ontario Government. The capital cost ($15 million) and yearly operating cost ($2 million) are less than the costs of an expressway system ($20 million per mile). The success in acceptance of this system (opened in 1967) suggests that a long-term plan for regional growth should include a system of commuter train lines, channeling development of satellite cities to key points on the system.

The planning for the BART System in San Francisco is cited as reflecting many of the zoning and development policies proven successful in Toronto's experience.

II-41.

Sheldon, Nancy W., and R. Brandwein, The Economic and Social Impact of Investments in Public Transit, Harbridge House, Inc., published by Lexington Books, Lexington, Massachusetts, 1973.

Summary

An overview of user, operator, and community benefits derived from improvements or extensions of public transportation, and summaries and analyses of case studies on rapid rail transit, bus transit, and commuter rail systems in U.S. metropolitan areas are presented. The authors suggest that frequently, though not always, public transit is a good alternative to highways in urban areas, providing broad social benefits (e.g., equality of access, increased economic vitality). It is suggested that for defined transportation objectives, rail rapid transit, as an alternative to automobile and bus transportation, ranks first in terms of total benefits. It is further suggested that use of Highway Trust Fund revenues to support public transit would be an equitable, socially responsible, and efficient policy decision.

Study Area and Investment

Case study summaries of rapid rail systems and of their impacts include the BART System, San Francisco; Broad Street Subway, Philadelphia; the Cleveland Transit System; the Washington, D. C. Metropolitan Area Transit Authority; the Chicago Area Transit Authority Subway Expansion Program; and the Massachusetts Bay Transportation Authority, Boston.

Aspects of bus transit service addressed include use of exclusive bus lanes (Shirley Highway, Washington, D. C.; Lincoln Tunnel, New York City); Dial-a-Ride service (Mansfield, Ohio; Peoria, Illinois - Flint, Michigan; Los Angeles, California); express bus service (Milwaukee, Wisconsin, Baltimore City, Maryland); new equipment; and quality of service.

Two operating commuter rail systems are also examined (Philadelphia-Lindenwold and the Skokie Swift Lines).

Methodology

The findings of previous studies relating to economic and social impacts of public transit are ordered in terms of goal-achievement analysis. The analysis includes the identification of community goals, translation of goals into achievable objectives, and the ultimate weighting of benefits.

Urban transportation objectives are defined, with respect to bus, rapid rail, and commuter rail transit, and expressed in terms of economic efficiency and equity. Individual programs, by geographic area, are then analyzed for evidence of specific impact on the transportation objectives.

Transportation objectives are categorized according to type of impacted group (i.e., user, operator, community). User benefits of public transit include: (1) equality of access to urban opportunities for the poor, elderly, young, and handicapped (comprising in aggregate 25% of the U.S. population); (2) time savings afforded by public transit (vs. automobile transportation); (3) cost savings; and (4) increased safety. Operator benefits from mass transit improvements include cost savings (operation and maintenance) and a decrease in vandalism and crime. Community benefits include benefits to nontransit travelers, for example, through decreased automobile congestion; increased employment; and real estate development. Other impacts are environmental (noise and air pollution) and impacts on land use planning.

Impacts

Rail Rapid Transit

The BART System in San Francisco has stimulated real estate development in the Market Street vicinity, where $1 billion in new construction has occurred in the past five years; in Oakland, where 4.3 million square feet of office space demand is anticipated over the next twenty years; and in Walnut Creek where suburban development is taking place. Residential property values have also increased approximately $1,500 for every ten minutes saving in travel time to major employment centers. It is anticipated that BART will carry 40% of all rush-hour traffic, reducing automobile congestion.

The subway station renovation program along the Broad Street Subway in Philadelphia is expected to attract ridership from other modes, and increase adjacent property values, reduce street congestion, and generally uplift the quality of life in the area.

The Cleveland Transit System, initially 14.9 miles in length and opened in 1955, now provides access to the downtown loop and to the Hopkins Airport. Extensions to this system have improved access to commercial and cultural facilities.

The Washington, D. C. Metropolitan Area Transit System is expected to improve greatly access to employment opportunities throughout the region, primarily through "reverse haul" service which is presently nonexistent. Nondiverted peak-period motorists (e.g., tourists) will benefit from reduced automobile congestion; the trucking industry will benefit through more efficient operation.

The Chicago Transit Authority's proposed subway expansion program (to be completed in 1978) is expected to generate real property value increases totaling $1.8 billion in 15 years, and 22,000 jobs (a 29% increase in the employment growth rate).

The Massachusetts Bay Transportation Authority recently completed a 15-mile South Shore extension. The benefits of this improvement include: elimination of a $1 million a year subsidy to the New Haven Railroad previously providing commuter service; new real estate development in Quincy, Mass., including a $100 million State Street Bank complex covering 80 acres; a reduction of commuter automobile traffic by at least 15%.

Bus Transit

The designation of an exclusive bus lane on an existing highway to maximize the movement of multiple-rider vehicles during periods of rush hour congestion has been implemented on Shirley Highway in Washington, D. C. and the Lincoln Tunnel, New York City, among other places. A survey of Shirley Highway bus riders indicated that 2 out of 3 persons were "choice" riders (had access to a car). The main user benefits are time savings, safety, and cost.

Express bus projects, supplying through-service along highways (e.g., for commuters and shoppers) have also been established experimentally. New, improved bus equipment and increased quality of service (e.g., more route selection) are cited as areas which could result in increased attractiveness of bus transit to potential riders.

Commuter Rail

The Skokie Swift, a rail rapid transit commuter service that shuttles from Skokie to Chicago, Illinois (5 miles), was originally opened in 1964 as a two-year public transit demonstration project. Anticipated ridership was 1,600 passengers daily, but actual ridership exceeded this estimate by three to four times. The system provided a transportation choice that equaled or exceeded the speed and convenience of available modes (automobile and bus) at a reasonable cost; opened job opportunities for central city residents; and provided feasible transportation to about 30% of the riders (2,400 persons) who formerly did not travel between Skokie and Chicago by any mode. Community benefits included increased employee stability for the firms near the line; an improved apartment rental market; and an opportunity for suburban expansion.

The Philadelphia-Lindenwold Line, a 14.5 mile commuter rail service opened in January 1969, now serves almost 40,000 riders per day, and has generated diverse real estate development in the suburban areas, and significantly reduced automobile congestion.

III-04.

Metropolitan Council of Governments (Washington Metropolitan Area), Department of Health and Environmental Protection, *Analysis of the Joint Interactions of Water Supply, Public Policy, and Land Development Patterns in an Expanding Metropolitan Area*, Final Report to the Office of Water Resources Research, U.S. Department of the Interior, September 1973.

Summary

Possible relations between sewer extensions and population growth in the Washington Metropolitan Area are statistically examined in the period 1960 to 1968. Simple statistical analysis by watershed suggests a relation between population growth and sewer capacity. A relation with higher statistical significance was obtained when the amount of vacant land divided by an average, straight line distance to trunk sewer service was also included. Analysis of the same data by EMPIRIC model districts does not yield results consistent with those found for watersheds.

Study Area and Investment

The Washington Metropolitan Area grew rapidly in population during the 1960-1970 decade. About 800,000 people were added (to a 1960 population of two million) and 50,000 acres of vacant land were converted to urban uses. Substantial sewer extensions were installed during the same period. For example, sewers in service in Montgomery County increased from 790 to 1,390 thousand miles while the population rose from 340 to 550 thousand; in Prince Georges County, sewer miles increased from 700 to 1,400 thousand while the population rose from 360 to 680 thousand.

Methodology

The EMPIRIC model was the basic framework for the analysis; EMPIRIC calibration data were a major part of the data base. In the EMPIRIC model, the Washington Metropolitan Area is divided into 'policy analysis districts' on the basis of transportation corridors. Changes in households and employment levels (divided into various categories) are allocated in 8-year intervals beginning in 1960. The model was calibrated for 117 districts (defined on the basis of 1960 census tracts) with data for 1960 and 1968.

The Washington Metropolitan Area was further subdivided in this study by a grid consisting of 2,000 foot squares. A computer program digitized and identified each grid square by the EMPIRIC calibration district to which it belonged. The impact of trunk sewers on development was analyzed in the first instance by considering development and trunk service for each grid square.

The impact of trunk sewer lines was quantified in terms of "gravity spheres" and hydraulic design capacity. A "gravity sphere" is the area potentially serviceable by a trunk sewer; it is defined by geographic drainage patterns (watersheds and subsheds), location of treatment plants, and location of forced mains and pumping stations.

Statistical analysis consisted of simple correlations between population and various measures of sewer service.

Impacts

The EMPIRIC model formulation for the Washington Metropolitan Area includes three relations involving water and sewer variables: (1) the change in share of lower-middle income households from 1960 to 1968 is linearly related to the base year (1960) share of sewered land multiplied by percent vacant land; (2) the change in share of upper income households is related to share of percent watered land in each district; and (3) the change in share of employment is related to the base year share of watered land divided by used land area.

Sewer data were collected in the present study for each grid square and were aggregated by watershed. Correlations were found between growth in a watershed, expressed as change in share of regional population, and change in design capacity; and between change in share of regional population in a watershed and a "composite capacity and location factor" including, besides change in hydraulic design capacity of trunk sewers, the amount of vacant land in the area during the base year multiplied by the inverse of its average straight line distance to trunk sewers.

When the same data were aggregated by EMPIRIC policy district rather than by watershed, no significant correlations of population growth (in terms of changes in regional share) to the "composite capacity and location factor" were found. A relatively poor correlation with change in design capacity was observed. A correlation with the reciprocal of the average distance of vacant land to sewer service was also observed. In general, however, analyses by watershed and by EMPIRIC district do not yield consistent results.

III-06.

Milgram, Grace, The City Expands, Institute for Environmental Studies, University of Pennsylvania, Philadelphia, Pennsylvania, prepared for the U.S. Department of Housing and Urban Development, March 1967.

Summary

The City Expands presents results of an empirical study of the rise in price of vacant land and its relationship to local factors. Time-distance to the central business district, proximity to public transportation, and availability of sewers were correlated with real estate values over an 18-year period (1945-1962) in a section of Philadelphia. Other factors, such as degree of development of the vacant land, its potential uses, and the type of buyer and seller also influenced prices.

Study Area and Investment

The area under study was the northeast sector of Philadelphia. It contains 25,000 acres, 17,000 of which were vacant in 1945, the base year of the study. By 1966, vacant land was essentially unavailable. Minor improvements in transportation and major sewer extensions were made in the study area during 1945-1962.

Exogenous Factors

The study cites several external forces at work that probably influenced development patterns and land prices. Most important, perhaps, was the strong growth pressure exerted on the Philadelphia Metropolitan Area following World War II. Much of the development that resulted from this pressure was channeled into the study area. Other potential external influences were large institutional land owners that withheld sizeable parcels from developers, and crucial zoning changes from low to high density residential use during the study period.

Impacts

The empirical evaluation of the impacts of infrastructure investments is limited to changes in land prices. Travel times to the CBD were used to reflect transportation improvements and access to trunk sewers to indicate sewer investments. Travel times were inversely related to land price per acre, with a 20 minute increase in travel time (25 to 45 minutes) showing an average four-fold decrease in land values. Land with access to trunk sewers was more than four times more costly, on the average, than land without such access.

The study showed that other factors, besides transportation and sewers, were important in determining land prices. The potential use of the land, as reflected in the size of the parcel transacted and its zoning, was strongly related to price. In addition, the existing degree of development of parcels, the type of owner and the type of buyer influenced land prices.

All these factors were combined in multiple regression equations to account for changes in land prices. The most accurate of these expressions explained 68 percent of the variation in price for residential land and 78 percent for commercial and industrial land. Access to trunk sewers and zoning for high intensity use were found to be the most important variables in the equations for residential land.

Methodology

The study was based on price data estimated from tax assessor records in time series from 1945-1962. The transactional history of each parcel was traced until the parcel was developed. Simple correlations of variables were established through standard statistical techniques, while elementary linkage analysis was used to determine factors which were most strongly related. Multiple regression equations were used to combine factors in explaining land price variations.

Conclusions

The study concludes that while infrastructure investments influence land prices and development, they cannot be used to control development. Zoning, on the other hand, can be used to restrain and direct development, but will encourage inflated prices if not adjusted to meet local market conditions.

III-10.

Stansbury, Jeffrey, "Suburban Growth--A Case Study," Population Bulletin, Population Reference Bureau, April 1972.

Summary

This article analyzes the influence of interceptor sewers on development in Fairfax County, Virginia, a southern suburb of Washington, D.C. Several major extensions of sewers into undeveloped portions of the county were followed by rapid, sprawl-type development. This in turn created intense pressure on public services in the region and helped increase tax burdens on existing residents. The study attributes these effects primarily to the sewer extensions, but also notes that ineffectual land use controls and growth-oriented county sewer authorities intensified the problems. Although not empirically rigorous, the study strongly suggests a relationship between sewers and development.

Study Area and Investment

Fairfax County, a southern component of Metropolitan Washington, experienced nearly a five-fold increase in population (from less than 100,000 to nearly half a million) between 1950 and 1970. The immigrants were largely accommodated in single-family houses priced between $30,000 to $40,000. Because of demand for low-density development, the hilly nature of the area, and the large reserves of undeveloped land, sprawl was dominant in the tidal wave of development.

County officials welcomed growth. In particular, the county sewer authorities took inflated population projections at face value and tried to anticipate growth by extending interceptor sewers into completely undeveloped portions of the county. The results, according to the study, were self-fulfilling population prophecies, with the sewer extensions stimulating enough residential development to achieve projected population levels. Land use plans were never seriously considered as restraints or even guidelines in locating new development.

Impacts

The study cites three specific secondary effects of interceptor sewers. First is the location of new development, which, the study claims, almost always occurred in new sewer service areas. Second is the intensity of development. The study describes how developers built at densities determined by the capacities of the new sewer lines. This had the additional effect of overloading treatment plants where the sewer capacities exceeded treatment plant capacities. Finally, sewer extensions created intense pressures on public services in the counties by stimulating sprawl development of new subdivisions.

This pressure caused either a decrease in per capita services or an increase of the tax rate.

The study suggests that sewer investments stimulate development by "subsidizing" developers (free wastewater collection facilities) and by generating financial pressures for further expansion. Sewer extensions are major capital investments, paid by bond issues, which must be repaid from hook-up and service charge revenues of the sewer line. In order to maintain an acceptable financial position, local authorities encourage new, intense development in service areas through zoning variances and informal agreements with developers. "Subsidy" and additional revenue reinforce each other, according to the study, so that development is almost inevitable.

In analyzing these events, the study acknowledges some purely local factors that encouraged the pattern of development. The county was under tremendous growth pressures from Washington, D. C., over which it had no control. The soils of the county are unsuitable for septic tanks; sewerage is a necessity for development. The county was financing sewers largely without federal assistance, which increased its indebtedness substantially. Finally, land use plans and controls in Fairfax County were ineffectual, partially because of unfavorable court decisions.

Conclusions

The major conclusion of the study is that "once trunk sewers have been laid down, subdivisions follow as mindlessly as mice after the Pied Piper." The particular complex of local conditions, including growth pressure from Washington, D. C., soil characteristics, and investment policies carried out during the study period, combined to make interceptor sewers a primary determinant of the location and intensity of new development. The study suggests that at the most basic level, developmental problems derive from the "growth is good" outlook of local government which considers all growth -- even unstructured sprawl -- as beneficial.

IV. MODELING TECHNIQUES

IV-06.

Center for Real Estate and Urban Economics, Jobs, People and Land: Bay Area Simulation Study (BASS), Special Report No. 6, Institute of Urban and Regional Development, University of California, Berkeley, 1968.

Summary

BASS is designed to measure the impact of a range of assumptions on land utilization in the multi-county San Francisco Bay Area. Residential and industrial location submodels allocate to regional subdivisions population and employment totals generated by regional growth submodels. Residential location is assumed to be entirely dependent upon accessibility to employment. Allocations of industrial changes, however, employ a variety of location criteria. Notable among the industrial allocation functions is the allocation of discrete facilities of manufacturing. Geographic subareas must first meet "essential" conditions for a given industry before they are evaluated relative to other candidate subareas.

Model Structure

BASS is composed of four submodels, two of which project employment and population totals for the region. Two others distribute these activities throughout the region.

Future regional employment of twenty-one classes of industry is forecasted in two ways. Past trends are extrapolated in one forecast; another set of projections is based upon various regional, state, and national variables. Either set of results can be used, or the two reconciled.

Birth and death rates are projected to obtain a first pass at future population. Externally forecasted labor force participation rates are then applied and the resultant labor force compared to the employment projection. Migration is then inferred from the difference, and the population adjusted accordingly.

The two remaining submodels distribute employment and population by regional subdivision. Employment in primary industries (e.g., agriculture, mining) is allocated using trend extrapolation. Construction employment is allocated in proportion to new housing and new employment in each zone. Relative attractiveness indices are computed for locating retail employment. These indices combine market potentials (generated by a gravity model) with measures of commercial site suitability. Suitability is calculated using regression analysis to calibrate weightings of factors such as density of development, accessibilities to employment and population (from matrices of inter-zonal travel times), and employment in certain other industries.

Allocation of manufacturing employment increases is a two-step process. Regional subdivisions are first examined for "essential factors" for each industry. Zones that pass this initial screening, are assigned attractiveness scores according to weightings of a variety of characteristics, including levels of employment, accessibilities, and land availability. The zone with the highest score receives an employment increase equal to the average size of the relevant manufacturing facility. This process continues until the entire regional increase has been allocated. Manufacturing declines, on the other hand, are allocated among zones according to the percentage of the relevant industry in the zone.

Population is allocated in proportion to each zone's accessibility to employment. Residential distribution is defined in terms of location of housing demand, with demand disaggregated into six classes. Each of two types of housing units (single- and multiple-family dwellings) is further subdivided into three value classes (high-, medium-, and low-income). Housing demolitions are forecasted exogenously. Constant proportions among value classes of housing are specified, and construction and filtering are formulated to maintain specified proportions.

Theories and Assumptions

In forecasting regional totals, it is assumed that migration is solely dependent upon the difference in natural population increase and "required" labor force. There is, therefore, no interplay between migration and employment. It is assumed, instead, that largely undefined regional forces that have operated in the past will continue to operate in determining future employment.

There is no competition among industry for sites in allocating manufacturing. "Clumps" of employment are allocated sequentially. It is assumed that manufacturing increases occur primarily in the form of discrete facilities.

The allocation of housing demands to zones assumes no effect of the supply of housing on those demands. BASS assumes accessibility to employment to be the primary location criterion for households.

Purpose and Applicability

The BASS model was designed to measure the impact [on land absorption or land use] of changing assumptions with respect to employment, incomes, household travel and spending behavior; public and private investments; and other variables affecting land absorption and utilization. A number of versions of the BASS model have been applied to the San Francisco Bay Area. PLUM (Projective Land Use Model) is a direct spin-off of the BASS modeling effort.

IV-07.

Chapin, F. Jr., "A Model for Simulating Residential Development," *Journal of the American Institute of Planners*, Vol. 31, No. 2, May 1965, pp. 120-125.

Summary

This formulation, commonly known as the University of North Carolina (UNC) model, addresses land conversion from open space to residential use. The model operates recursively over time, probabilistically allocating households to sub-areas according to measures of relative attractiveness, including accessibility.

Model Structure

The study area is divided into a grid with each cell first classified according to its availability for residential development. A cell may be unavailable because of previous development, plans for non-residential use, or plans to preserve open space. The remaining cells are assigned attractiveness scores by a linear combination (calibrated by regression analysis) of initial assessed value, accessibility to work areas, availability of public sewers, and accessibility to schools and major streets. The probability of residential development is taken to be proportional to the attractiveness of each cell.

As the model operates over time, components of each attractiveness score are revalued for each time period. Units of development are allocated sequentially to cells within each time period.

Theories and Assumptions

The formulation assumes that development is constrained by demand for residences, that is, there is no speculative housing construction. Development is represented as a sequential process without competition for sites and, consequently, no effect of supply on demand through a pricing mechanism.

A subsequent version of the model disaggregates population, but maintains the assumption that all population groups have the same locational criteria. The location of each group, however, is limited to a specific subset of cells.

Purpose and Applicability

The UNC model addresses land use succession, but is applicable only to new residential development. Within that context, land use regulations and alternative development plans can be tested for their effect on residential development.

IV-08.

CONSAD Research Corporation, Impact Studies: Northeast Corridor Transportation Project, Volumes I, II, III, IV, Prepared for Northeast Corridor Transportation Project, Office of High-Speed Ground Transportation, U.S. Department of Transportation, 1967, 1968, 1969, 1970.

Summary

The Northeast Corridor Transportation Project (NECTP) model was designed to forecast the impact of various transportation systems in the Northeast Corridor of the United States on population, economic activity, income, and land use. The model emphasizes the concept of "comparative advantage" of alternative locations in determining geographic distribution of activities. A non-spatial model of economic activity (ECON) provides inputs to an intraregional location model (INTRA). Regression analysis is used to calibrate econometric equations in both models.

Model Structure

At the highest level of geographic aggregation is an econometric model (ECON) that projects demand for industrial output and labor for nine industrial sectors in the Corridor. The intraregional location model (INTRA) allocates employment (by sector), population, income, and land use (residential, commercial, industrial) by geographic location. An interregional input-output model (IRIO), part of the original NECTP formulation, was subsequently deleted.

INTRA, a set of highly interrelated components, produces a time-stepping simulation. Changes in employment distribution are based upon counties' relative advantages in procurement, processing, and distribution. Procurement advantages are dependent upon accessibility to inputs required by each industry. Processing advantages are determined by relative costs of production factors, particularly land and labor. Distributional advantages depend on the market potential (for final products or intermediate goods) of an area and on accessibility to the area market.

Births, deaths, and migration determine county population levels. Births and deaths are formulated as dependent upon population densities and income levels. Migration is generated by feedback from county unemployment, accessibility to employment, and wages. Wage and property incomes, the primary components of personal income, depend on factors such as unemployment and density of land use, which represent supply-demand interactions in the markets for labor and land, respectively.

In forecasting land use, a simple relation to accessibility and density was used after attempts to calibrate more complex equations failed.

Theories and Assumptions

Two major concepts shaped the NECTP work. The first is the use of a comparative advantage framework. Location decisions are based not only upon absolute values of determinant factors, but also upon the relative advantages offered by different locations.

The second principle is the large amount of interdependence between the components of the system. Evolution of the original INTRA Model to the stage reported here was based on an explicit recognition of feedback between population, employment and personal income.

Purpose and Applicability

The NECTP modeling effort was designed to provide forecasts of impacts of various transportation systems in the Northeast Corridor on geographically-disaggregated levels of population, industry, personal income, and land use.

As of the last cited reference (1970), the model was not considered directly usable as a practical tool for forecasting.

IV-12.

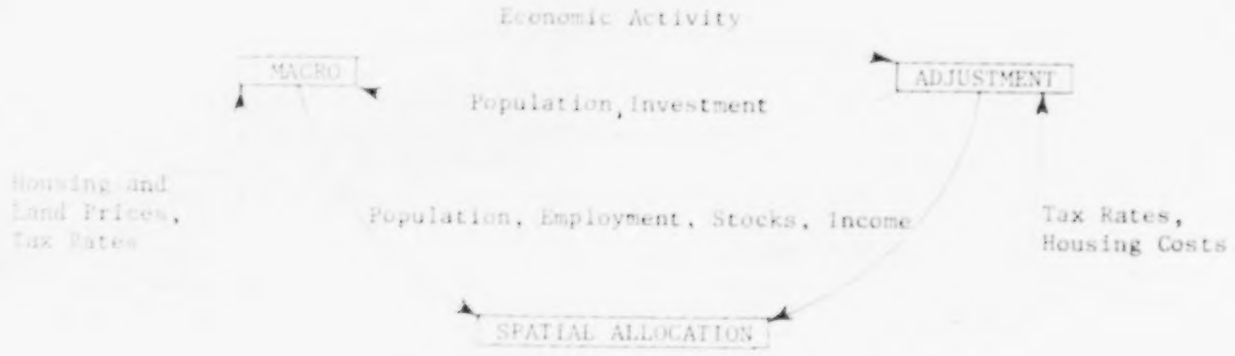
Engle, Robert F. III, Franklin M. Fisher, John R. Harris, and Jerome Rothenberg, "An Econometric Simulation Model of Intra-Metropolitan Housing Location: Housing, Business, Transportation, and Local Government," American Economic Review, Volume LXII, Number 2, May 1972, pp. 87-97.

Summary

The system of models proposed by the authors is intended to permit the evaluation of policy alternatives at different governmental levels with respect to the development of Boston. A set of models is outlined that would provide regional forecasts of activities and of their distribution within the region. The intraregional location model addresses dynamic market processes involving durable housing structures. The colocation of housing with other zonal attributes is an important consideration in location decisions. Two other models--the macroeconomic and long-term adjustment models--provide population, employment, and income as inputs to the allocation model.

Model Structure

A three-model system is proposed: a macroeconomic model (non-spatial) of output, employment, and income; a model of long-term adjustments in population and capital stocks; and a model of spatial allocation of social and economic activities. The models are structured in a feedback system, as illustrated below.


Economic Activity
MACRO
ADJUSTMENT
Population, Investment
Housing and Land Prices, Tax Rates
Population, Employment, Stocks, Income
Tax Rates, Housing Costs
SPATIAL ALLOCATION

The macroeconomic model sets forth a series of relationships, which are identified below.

income = f (value added in eight groups of industries)

industry's value added = f (other industries, commodity prices, income)

manufacturing employment demand = f (value added in manufacturing, capital investment, productivity)

other industries' employment demand = f (value added, wages, productivity)

labor force participation = f (population, age, sex, race, wages, prices)

wages = f (unemployment, prices, technology)

prices = f (housing costs, costs of services, commodity prices)

housing costs = f (land and structure prices)

costs of services = f (wages)

commodity prices = f (unemployment, national commodity prices)

The output provided by this model is in terms of value added and employment (by industry), income, and income distribution.

The long-term adjustments model provides changes in population (through migration and natural increase) and capital investments. Both migration and investments are affected by wages, prices, and unemployment relative to the U.S. as a whole. In addition, investments are affected by regional manufacturing value added and interest rates.

In the spatial allocation model, the Boston region is divided into zones of geopolitical units (e.g., towns or counties). Industrial land users are broken down according to the disaggregation employed in the macroeconomic model (eight types). Households choose between three levels of quality for housing. Given land use and zonal preferences, each industrial and household group evaluates zones for characteristics such as housing, taxes, public expenditures, and accessibility. Housing supply is governed by decisions based upon the profitability of construction or conversion.

Theories and Assumptions

A geographical hierarchy is established in the model in which people and industry make location and investment decisions first at the regional level, and then make intraregional location decisions on separate grounds. The focal point of this model system is spatial allocation.

The allocation model is based on location of zonal attributes. This approach recognizes the fact that different attributes of a zone, such as public services and accessibility, must be evaluated by potential residents as an indivisible "bundle."

Housing is treated as a durable, with the major portion of the stock resulting not from (instantaneous) new construction, but from previously standing stock. The interaction of supply and demand in housing submarkets is the primary determinant of adjustments to the standing stock.

The dynamic structure of the model allows explicit treatment of market processes involving land, housing, and labor.

Purpose and Applicability

The stated purpose of the full model is to permit systematic evaluation of a very wide range of policy alternatives considered at national, state, metropolitan, or local jurisdictional levels.

As this model has yet to be completed, it is difficult to determine the ease with which the final product will be applicable. Some equations have been estimated, but most of the formulation is still at the conceptual stage.

IV-14.

Forrester, Jay W., Urban Dynamics, M.I.T. Press, Cambridge, Massachusetts, 1969.

Summary

A dynamic simulation model is presented for potential application to analysis of the effects of public policies on the development of cities. The model emphasizes interdependence among components of the system and feedback. Particularly notable is the formulation of changes in relative "attractiveness" of an area as the result of decisions based upon past attractiveness.

Major components of the system are population, industry, land availability, housing, and taxing policies. The overall behavior of a hypothetical city is characterized by stages of growth, stagnation, and eventual decay. Governmental policies, including job training and slum demolition, are tested with the model.

Model Structure

The most distinctive features of the Urban Dynamics Model are the predominance of feedback loops and the causal relationships between major variables. Industries are divided into three groups by age, housing into three classes by value, and population into three skill levels. There is no geographic disaggregation.

The city's population is determined by birth, death, and migration rates. Migration is a function of the attractiveness of the city relative to all other areas. The city's attractiveness depends on job and housing availability, public expenditures, and taxes.

The relative attractiveness principle is also applied to industrial growth. Industrial attractiveness depends upon labor and land availability, tax rates, and recent industrial growth.

The housing stock is generated by construction, changed by filtering, and severed by demolition. Construction depends on demand for each class of housing, land availability, speculation, and tax rates. Filtering of housing to a lower value class occurs in times of adequate supply in a higher class. Demolition occurs as land is needed.

Theories and Assumptions

Two major theories permeate the formulation: the attractiveness principle and feedback relations. The attractiveness principle assumes that the relative advantages and disadvantages of areas tend to become equalized as people and industries respond to a previous disparity in conditions. For example, migration from one area to another affects both areas by increasing the lower attractiveness of the former and decreasing the higher attractiveness of the latter.

The second theory that shapes the model is that feedback among the variables governs system behavior (growth of the city).

An explicit assumption of the model is that the city is a "closed" system: that is, its behavior is primarily determined by causal forces internal to the system. Thus, it is assumed that people who work within the city also live there; and that public services are supported uniformly throughout the area by taxation of residents. External factors may affect specific values of variables, but the basic modes of behavior (growth, stagnation, and decay) remain unchanged. Much of the criticism of the model has been aimed at this point. The relatively narrow geographic boundaries of the model preclude any explicit interaction between the city and surrounding areas. Forrester's assumption of a self-enclosed urban system of jobs and people is questionable given the accessibility afforded by modern transportation technology.

Purpose and Applicability

The model is presented as an example of a methodology which could eventually provide the capability for comprehensive analysis of the effects of various public policies. Such policies include taxation, housing programs, and job training. The model in its present form treats only in a gross manner the effects of transportation investments and zoning policies, since there is no areal breakdown.

The formulation, essentially unchanged in scope and content, is currently being tested for validity and projective capability in an application to Lowell, Massachusetts. Research into varying postulated relations, expanding the geographic boundaries, and changing the component variables of the model has been conducted by many, among them Hester, Kadanoff, and Garn.

IV-21.

Hamilton, H. R., S. E. Goldstone, J. W. Milliman, A. L. Pugh III, E. B. Roberts, A. Zellner, Systems Simulation for Regional Analysis: An Application to River-Basin Planning, The M.I.T. Press, Cambridge, Massachusetts, 1969.

Summary

A regional simulation model designed to analyze the economy of the Susquehanna River Basin treats dynamically a number of interrelated regional factors. The model is composed of a series of "subregional" models, each of which consists of highly interdependent economic and demographic sectors. A sector of upstream-downstream water quality and quantity provides the only link among subregional models.

Model Structure

Each subregion includes several counties. The subregional models were formulated, therefore, as essentially independent of each other with respect to labor force/employment interactions. Only the effects of water quality and quantity in different sections of the river basin are regional.

Population is disaggregated into age groups homogeneous with respect to migration, labor force participation, birth, and death rates. Industries are divided into export and local industries. Local industries are further broken down into household- and business-serving. Export industries are disaggregated into groups according to the significance of the following costs in the operations of each: labor; transportation of products to markets; and transportation of raw materials to processors.

Population growth in each age class depends on births, aging, deaths, and migration. Birth and migration rates are affected by subregional unemployment. Labor force participation also depends on unemployment (the discouraged-worker effect). A cumulative measure of skills is computed for each subregion, reflecting a greater tendency to migrate among more highly-skilled people.

Transportation costs are specified exogenously for the model. Labor costs (wages) depend on unemployment (as an indicator of the labor market) and the mix of industries. Required transportation and labor expenditures constitute the subregional attractiveness measure for export industry groups. The level of household-serving industries is derived from subregional population, while business-serving employment depends on the levels of all other industries.

Theories and Assumptions

The formulation was based on the theory that many dynamic interdependencies exist between a large number of economic and demographic components of a regional system. Emphasis was placed on developing classes of population and industry which react similarly to the same set of conditions.

Purpose and Applicability

The model was constructed in order to analyze the economy of the Susquehanna River Basin and to define the role of water resources in its future development.

Potential applications include the analysis of the effects of various types of public investments, such as in transportation or education. Many other applications are suggested by the authors, each of which would require some refinement or expansion of an appropriate portion of the model. Examples include: expansion of the labor market formulation to analyze manpower programs; consideration of resource problems other than water, such as forests, land, minerals; and inclusion of a government sector to study state and local taxation and fiscal policies.

The Susquehanna work has, in fact, spawned further modeling efforts. The water sector was reformulated in RIVERZ, an application to the Grand River Basin; was directly adapted to an analysis of the St. Louis area; and a similar model, with population further disaggregated by occupation, was used in an analysis of Kent County, Michigan.

IV-23.

Hill, Donald M., "A Growth Allocation Model for the Boston Region," Journal of the American Institute of Planners, Special Issue, Volume XXXI, Number 2, pp. 111-120, May 1965.

Summary

The EMPIRIC Land Use Model for the Greater Boston Region is described and initial calibration results are summarized. The model allocates growth of white- and blue-collar population groups, retail and wholesale, manufacturing, and other employment by subzone within the region. "Locator variables" are intensity of land use, zoning practices, automobile and transit accessibilities, and quality of water service and sewer service.

Future growth in each subregion is projected in short steps, with each step depending upon the results of previous steps. The development of each activity in each subregion influences future development by way of competition for land and changed accessibilities. The initial analysis used for establishing the parameters for the model is based on multiple correlation, and shows extremely close correspondence between estimates generated by the model and historical events. When the model is used as a projection device, current trends do not continue, but are changed by later events.

Model Structure

The model assumes that location of population, employment, and other activities are interrelated in a systematic fashion. Interrelationships of activities are assumed to be additive and are incorporated in the model in a linear form.

Population and employment activities ("located variables") are forecasted for each subregion at the end of a given forecast period; the location and intensity of these variables are determined by the presence, absence, or ease of access to other influencing activities ("locator variables"). The change in the subregional share of each located variable in a subregion is taken to be proportional to: (1) the change in the subregional share of all other located variables in the subregion; (2) the change in the subregional share of a number of locator variables in the subregion; and (3) the value of the subregional shares of other locator variables. The proportionality constants are determined by simultaneous regression analysis of data taken at two past points in time. Each located variable is thus calculable from a linear equation with fixed coefficients.

Future subregional values of each located variable are calculated by substituting in each equation the pertinent values of the locator variables for the subregion and solving the equations simultaneously for the subregional located variables. To obtain forecasts in absolute values, subregional shares at the end of the forecast interval are multiplied by externally forecast figures for the total change in the located variable for the whole region.

Study Area and Methodology

The Greater Boston Region, consisting of 152 cities and towns, an area of 2,300 square miles, and a population of 3,400,000, was divided into subregions for model validation testing. Initially, 29 subregions were used and three sets of locator variables were tested over the period 1950 to 1960. The first test used 1950 data on location and density of population and employment, and 1950-60 data on changes in land use density, zoning practices, and highway and mass transportation systems. The second test deleted transit accessibility as an input variable; the third test added water supply and sewer service as input variables, and retained transit accessibility.

Each of these sets was then tested for varying time periods (5 or 10 years). The third set of input variables was tested for varying forecast periods (10, 20, or 40 years); the second set of input variables was tested by varying the number of subregions.

Three indices were used to measure aggregate correspondence between observed and predicted values: the Root Mean Square Error (RMS); the RMS Error Ratio; and the Coefficient of Determination (R^2).

Results and Conclusions

Model calibrations, using 29 subregions and forecasting historical growth from 1950 to 1960, showed a close correspondence with actual growth figures. The first formulation (including zoning, land use, automobile and transit accessibilities as locator variables) predicted both growth and decline in the region, including a loss of approximately 100,000 people and 30,000 jobs in the City of Boston. The RMS error measure was 1,439 people (total population) and 1,512 jobs (total employment). RMS error ratios were .03 for both totals.

The second model formulation (transit accessibilities not included as locator variables) resulted in RMS error ratios of .07 for population and .08 for employment. The third formulation (including water supply and sewer service) resulted in RMS error ratios of .01 for population, and .01 for employment.

Each of the above formulations was tested over shorter historical time periods (1950-1955). The first and third set formulations showed decreased accuracy for the five vs. ten year periods; the second formulation (not including transit or water supply and sewer services) increased in accuracy (the RMS error ratio for population decreased from .07 to .03). This latter calibration was then used recursively and non-recursively for forecasts over a series of time periods (1960-70, 1960-80, 1960-2000). Single projections tended to show curvilinear trends, while recursive projections diverged from this trend. Generally, recursive techniques are assumed to be more sensitive to policy changes, and thus, more accurate.

The third formulation (including all locator variables) was tested using 123 and 134 subregions. Accuracy was less than with the original 29 subregions.

IV-27.

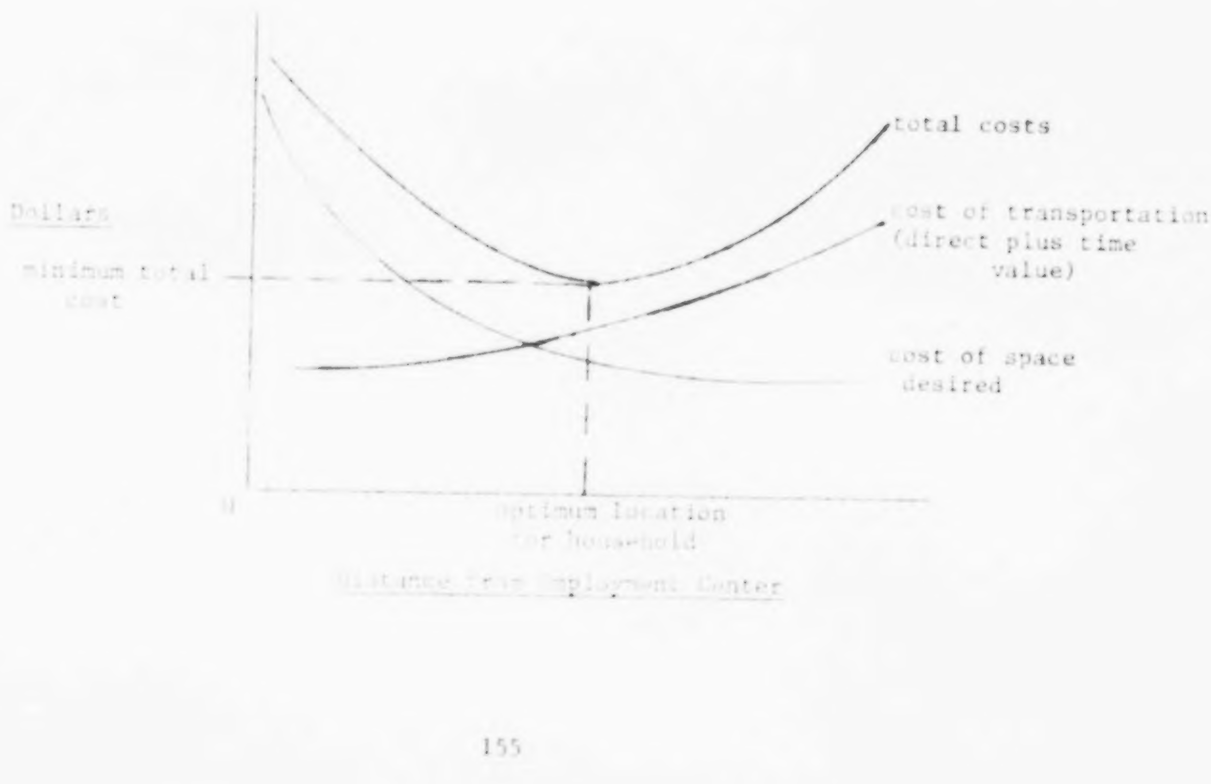
Kain, John F., "The Journey-To-Work as a Determinant of Residential Location," Papers and Proceedings of the Regional Science Association, Volume 9, pp. 137-160, 1962.

Summary

The model is an attempt to explain residential distribution by a theory of household location based on journey-to-work travel. Households are assumed to minimize total costs, consisting primarily of the cost of transportation, which is assumed to increase with the distance to the workplace, and the unit cost of residential space, which is assumed to decrease with distance to the workplace. The expected static equilibrium solution is in good agreement with data on the distribution of households across a series of concentric zones in Detroit, Michigan.

Model Structure

The equilibrium model proposed by Kain provides a distribution of households over concentric zones in a metropolitan area. The basis of the model is an algorithm that minimizes total household costs, composed of journey-to-work costs and location rents. The quantity of land desired by households is determined from household characteristics, such as income, race, and family size. The minimum cost location of the corresponding amount and type of land is defined by cost functions represented in the following diagram.



The distance from the CBD at which total costs are at a minimum determines the concentric ring in which the household locates.

Theories and Assumptions

Transportation costs are derived from a series of assumptions. Transportation expenditures are assumed to be composed of three components, each consisting of direct travel costs and dollar valuations of time. The three primary components are: (1) costs which vary according to distance to the workplace; (2) expenditures for services obtainable in the residential area; and (3) costs which vary with the residence's distance to points outside the residential area. Of these, (2) is assumed to be invariant over all residential zones in the region, and (3) is assumed to be trivial. The remaining factor, the journey-to-work, defines, therefore, transportation costs for most households.

In treating the market for residential space it is assumed that the price per unit of a given quality of land decreases with distance to workplace. Workplaces are assumed fixed and predetermined for each household. Given a density preference, households are assumed to maximize utility by minimizing costs.

Finally, it is assumed that other variables such as the quality of housing and of local government services are derived from demand, and are not determinants of residential location.

Purpose and Applicability

The model, as presented in Kain's paper, advances a theory of locational criteria to explain existing residential distribution. Data on Detroit households were examined and found to be consistent with the theory. The theory can be incorporated in a projective model, as was done in the NBER Simulation, which included other locational criteria, relaxed the monocentric assumption, and provided a dynamic formulation.

IV-28.

Kain, John F. and Gregory K. Ingram, The NBER Urban Simulation Model as a Theory of Urban Spatial Structure, Preliminary Draft, National Bureau of Economic Research, Inc., October 1972.

Summary

Urban area housing markets are modeled by simulating the interaction of housing supply and demand. Kain's journey-to-work theory is incorporated in the dynamic simulation model. Housing and neighborhood characteristics are additional location criteria. A linear program minimizes total travel costs to obtain the distribution of residential demand. Supplies of housing are governed by the profitability to landowners and developers of construction, filtering, and transformation.

Model Structure

The NBER model is a dynamic simulation of urban housing markets. Exogenous employment changes generate households, some of which move in a given time period. Each household type has a preference for a housing "bundle" consisting of attributes of the structure and the neighborhood. Bundle prices are composed of housing prices, travel time and its valuation, and direct travel costs. Travel costs are based upon the distance to work and the available travel modes. A linear program minimizes total travel costs to obtain residential distribution given bundle preferences and bundle prices throughout a region.

Supplies of different types of housing in different locations depend upon construction, filtering, and transformation. For each housing bundle, the profitability of building new units and of maintaining or transforming existing units is evaluated. The costs of each such operation are externally specified. Expected income from properties is determined by prices in the appropriate housing submarkets. Subsequent supplies of housing bundles are determined, therefore, by the economic feasibility of construction, maintenance, and transformation. The difference between supply and demand in each housing submarket determines housing bundle price changes.

Theories and Assumptions

Kain's original journey-to-work theory is reflected in the NBER model. The original assumptions of a monocentric city and an equilibrium solution are abandoned in favor of multiple workplaces and a dynamic interplay of supply and demand in housing submarkets. In addition, housing and neighborhood characteristics are explicitly represented as determinants of location. The household's preference for "bundles" is a function of the social and economic characteristics of the household.

Purpose and Applicability

The model is presently designed to simulate urban area housing markets, but extensions to the model are planned. These include endogenous formulations of non-residential land use, population-serving employment, and neighborhood attributes.

The Impacts of housing programs can be addressed by the model as presently reported. The effects of discrimination, varying local public services, and land use policies can be addressed more extensively after the planned expansion of the model.

Experience with the Detroit prototype model pointed out serious calibration problems. Using Pittsburgh data, there was some improvement, but difficulties remained in specifying the crucial equations for housing bundle demands, particularly with respect to the effect of the quality of local public services on bundle preferences.

IV-29.

Kaiser, Edward J., A Producer Model for Residential Growth, Center for Urban and Regional Studies, Institute for Research in Social Science, University of North Carolina, Chapel Hill, N.C., November 1968.

Summary

A producer oriented model based on discriminant functions is formulated from empirical results obtained for two North Carolina cities. A linear combination of four predictor variables (socio-economic rank, distance to nearest elementary school, index of accessibility to employment areas, and availability of public utilities and services) was used to calculate probabilities of single family, subdivision development. The equation, calibrated from historical data, predicts development with an accuracy of only 52% for small-developer subdivisions, but with 92% accuracy for large-developer subdivisions (random choice is 50%).

1. Empirical Studies

Study Area and Investment

Single family subdivision development is examined in Greensboro and Winston-Salem, two medium-sized cities (approximately 120,000 population), during 1958-1963.

Methodology

A circular area, about seven miles in radius and centered on the high value corner of the Central Business District (CBD), was divided in about 4,000 cells by a square grid 1,000 feet on each side (each cell was about 23 acres). Subsamples of about 500 cells were selected from each set. In the case of Greensboro, subsamples over two periods (1958-61 and 1961-63) were used; data for Winston-Salem covered 1961-63. Ten independent variables (proportion of marginal land, poor soil, socio-economic rank, distance to nearest major street, distance to nearest elementary school, accessibility to employment areas, distance to the CBD, contiguous residential development, availability of public utilities and services, and zoning protection) were examined using Kendall's tau(c) as a univariate index of order-association between site characteristics and subdivision type. A stepwise discriminant computer program was used in multivariate analysis.

Intervening variables included market type (subdivision in low or high price range), developer type (small or large developer), and contextual factors (macro-environmental setting of each city).

Discriminant analysis was used to classify each observation into subdivided or unsubdivided groups; comparison to actual observations yielded percent of correct classification. Probabilities of subdivision were calculated from values of predictor variables in a given period and calibration data obtained for an immediately preceding period. Comparison to actual occurrence of subdivision yielded percent of correctly classified (predicted) outcomes.

Results

Univariate analyses show that socio-economic rank is the single most important variable determining subdivision development. Distance to nearest major street, amount of contiguous residential development, availability of public utilities, and zoning protection were also statistically significant.

Statistical analysis also showed that the locational decisions of large developers are different from those of small developers: the former are more strongly related to site characteristics, particularly to socio-economic rank, availability of public utilities and zoning protection.

Multivariate analyses generally support the results of univariate tests.

II. A Producer Oriented Model

Model Structure

Probabilities of residential (single family) development for cells about 25 acres in area are obtained from discriminant functions consisting of a linear combination of four predictor variables (socio-economic rank, distance to nearest elementary school, accessibility to employment areas, and availability of public utilities and services). The equations are calibrated for one 3-year period and used to predict development during a subsequent 3-year period.

Theories and Assumptions

The model is based on empirical findings showing that locational and institutional (but not physical) site characteristics are statistically significant at the .01 level or better for single family subdivision development. Developer type (size) and price are also significant.

Applications

The model can be used to forecast locational tendencies of residential subdivision development given alternative public policies on spatial distribution of water and sewerage systems, schools, segments of the transportation network, and zoning districts.

Limitations

Since the model was derived from empirical findings in only two geographic areas, it is somewhat inconsistent with expected associations and with some results in the literature.

The model is a partial one, biased to the developer's point of view, and treats only spatial distribution (and not amount) of only one sector of the residential market (new, single family subdivision development). It is not an allocation model and it cannot be used recursively over time. It cannot forecast over a substantial length of time. Finally, since contextual factors are significant, the model must be calibrated separately for each urban area.

IV-32.

Lakshmanan, T. R. and W. G. Hansen, "A Retail Market Potential Model," *Journal of the American Institute of Planners*, Volume XXXI, Number 2, pp. 134-143, May 1965.

Summary

A gravity model was developed to examine economic feasibility of large commercial centers in Baltimore by determining potential markets in the metropolitan region. Possible sites, selected on general planning grounds, are tested by volume of business attracted in relation to center size. It is shown that a balanced distribution exists which depends on the distribution of purchasing power predicted for the region and the available transportation facilities. The balanced distribution minimizes costs for trip-makers.

Model Structure

The sales potential of a retail center is taken to be directly related to its size, to its proximity to consumers, and to the income levels of potential consumers. The sales potential is also related to the center's location vis a vis other competing facilities. Mathematically, these relations are expressed as direct proportionalities of sales to size and consumer expenditures and inverse proportionalities to distance to consumers and to size and location of competition.

A key variable of the model is the consumer-retailer interactive space, defined operationally by the driving time between the consumer's zone and the retailer's zone on the highway network.

Theories and Assumptions

The gravity or "intervening opportunities" formulation was selected to represent the theory that the market area for a retail center is not an "arbitrary spatial slice of the region," but extends throughout the entire region. The greater the distance to the consumer and the larger the competition, the less business a given retail center will receive from the corresponding portions of the market area.

Projections with the model assume that implicit factors, such as public policies and consumers' locational and spending patterns, will remain the same.

Purpose and Applicability

While it is not specifically intended as a projective tool, the model can be calibrated to incorporate external projections affecting future market potentials. Such a formulation may be incorporated in a more comprehensive regional model, or stand alone and employ judgementally derived projections.

IV-35.

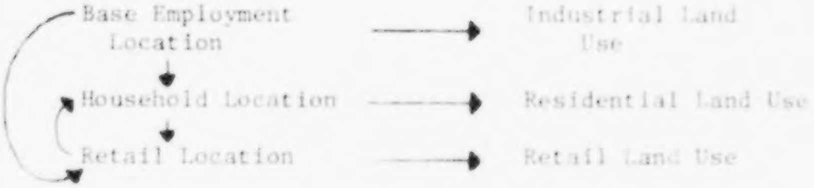
Lowry, Ira A., A Model of Metropolis, RAND Corporation, Santa Monica, California, 1964.

Summary

The Lowry model, widely known for its simple and logical causal structure, was, in its original formulation, an attempt to determine the equilibrium distribution of households and retail activity. An iterative computational sequence is used which converges to a balance between places of employment and residences.

Model Structure

The iterative sequence employed in the Lowry model is illustrated below.



The location of base industry is specified exogenously. Households are allocated to zones in proportion to each zone's accessibility to employment locations (only base employment in the first iteration). Retail activity (employment) location is then dependent upon accessibility to industry and households, subject only to the constraint of a minimum amount of retail employment which must be generated for a zone before retail industry can locate in that zone (reflecting economies of scale). Retail industry adds to employment opportunities; residential distribution (according to employment accessibility) is redefined accordingly, which further alters retail location, etc.

A conversion factor for each activity determines land use in each zone. Base industry has first priority in land use, followed by retail industry and then households. A maximum density constraint is imposed upon residential land use.

Three types of retail activity, differentiated by size of the market each serves (neighborhood, local, metropolitan) are located with the model. Base industry and households are not disaggregated.

Theories and Assumptions

A basic/retail division is adopted for differentiating industries in terms of land requirements and dependence upon residential distribution. In expressing the interdependence of activities' locations according to accessibility, straight-line distance from zone center to zone center is used as the accessibility measure.

A number of assumptions govern land use specifically. Higher-intensity uses (base and retail industry) have priority in each zone. Residential density may not exceed a maximum for any given zone, while retail industry may use up all available land and continue to increase (presumably by more intensive use of existing facilities or by multi-story facilities).

Purpose and Applicability

The Lowry model provides an equilibrium distribution of land-using activities, thereby ignoring issues of land use succession. The effects of different assumptions regarding base industry location and zoning may be tested with the formulation. Effects of transportation investments cannot be examined as such, since interzonal air distances are used in measuring accessibility.

In its initial form, the model had relatively few data requirements. It was applied widely and generally successfully. Revisions of the model have added to the original conceptual formulation. The Time-Oriented Metropolitan Model (TOMM) disaggregates population by income and changes the model to a dynamic simulation. Other efforts inspired by the Lowry model are the Bay Area Simulation Study (BASS) and the Projective Land Use Model (PLUM).

SECTION 3

ANNOTATED BIBLIOGRAPHY

I. HIGHWAYS

A. Economic

A-01. Allen, J. K., and R. Hoffman, Impact of Improved Highways on the Economy of the United States, Stanford Research Institute, Menlo Park, California, September 1958.

A comprehensive analysis of the impact of improved highways on the general economy of the United States. Economic effects benefitting directly and indirectly from improvements are described; and indirect benefits are examined in terms of land use, land value, site preferences, business and industrial opportunities, employment, national defense needs, and governmental services.

A-02. Arkansas Highway Department, U.S. 70 Bypass — Glenwood: An Economic Impact Study, prepared in cooperation with the U.S. Bureau of Public Roads, 1961.

A before-and-after study of impacts of a bypass highway on the town of Glenwood, Arkansas. The study concludes that overall effects are beneficial as evidenced by increases in retail trade; improved industrial transportation services; reduced traffic congestion; and increased land use and value.

A-03. Bardwell, G. E., and Merry, P. R., "Measuring the Economic Impact of a Limited Access Highway on Communities, Land Use and Land Value," Highway Research Board, Bulletin 268, pp. 37-73, 1960.

An analysis of the economic impact, based on sales tax data by type of business from 1946 to 1957, of highway bypasses around seven small Colorado towns. Also included is a discussion of the effects of highway improvements on rural land use and land value along U.S. 87, based on the sale of land parcels during the same period. Land sales are classified by use, location, size of parcel and price.

A-04. Bielle, C. W., and Moses, L., "Transportation and the Spatial Distribution of Economic Activity," Highway Research Board, Bulletin 311, pp. 77-90, 1962.

An examination of the overall pattern of locational change of manufacturing firms in the Chicago metropolitan area. Industrial relocation, expansion, and new location in this area from 1950 to 1960 are treated in terms of distance from the central business district (inner city, city fringe, and suburban areas). Forces affecting relocation decisions of firms are discussed and hypotheses of locational change are tested.

A-05. Bone, Alexander J., Economic Impact of Massachusetts Route 128, M.I.T. Transportation Engineering Division, Cambridge, Massachusetts, 1958.

An investigation of land use changes (industrial and residential) along the circumferential highway built during 1933-1951 and an evaluation of the impact of these changes on the Boston metropolitan area as a whole.

A-05. (Continued)

Route 128 encouraged Boston area companies to relocate to newly accessible suburban locations. About three-quarters of Route 128 companies relocated from the Boston metropolitan area. Thus, in examining net changes in industrial development, it is estimated that the area gained as a whole, but the central city suffered a net loss. Residential development (in terms of wealth, density, and land values) in two towns near the highway was significantly higher than in control areas.

A-06. Bowersox, D. J., "Influence of Highways on Selection of Six Industrial Locations," *Highway Research Board*, Bulletin 268, pp. 13-28, 1960.

An examination of the influence of highways on industrial location. Plant location procedures used by six Michigan industrial firms in 1957 and 1958 are studied and general trends in the use of highways by industry, as well as specific considerations in plant location (e.g., access to markets and space availability) are discussed. The surveyed firms considered highway facilities important but not critical in their decision-making. Several examples of significant industrial development after highway construction are noted (e.g., Route 128 and the New York Thruway) and their analytical case studies presented.

A-07. Britt, Robert D., "Promises and Accomplishments: The Appalachian Regional Development Program," *Growth and Change: A Journal of Regional Development*, Vol. 2, pp. 3-13, July 1971.

An examination of the goals of the 1965 Appalachian Regional Development Act and progress through 1970. The role of highways in the program is discussed in relation to the area's problems of economic depression, out-migration, low education levels, health and child development, housing, and resource and environmental projects. Highway expenditures accounted for 60% of initial authorized funds; 12% of the highway system was completed in 1970.

A-08. Buffington, J. L., *A Study of Economic Impact of Interstate 45 on Huntsville, Texas*, Texas Transportation Institute, Texas Highway Department, August 1966.

A study conducted in 1959 on effects of a bypass on Huntsville, Texas. Overall growth of Huntsville was not impaired although highway-oriented business on the old highway (U.S. 75) was adversely affected.

A-09. Buffington, J. L., *A Study of the Economic Impact of Interstate Highway 45 on Conroe, Texas*, Texas Transportation Institute, Texas Highway Department, August 1966.

Economic effects of a bypass of Conroe, Texas as illustrated by changes in land use and value, business, travel, and general community behavior. Impacts were generally significant and positive.

A-10. Buhl, W. F., "Intercity Highway Transport Share Trends to Vary Inversely with Size of Plant," *Highway Research Record*, Number 175, pp. 9-14, 1967.

Analysis of about one million shipments drawn from files of about 10,000 firms shows a significant inverse relation between size of manufacturing plants and relative use of highway transport for outbound shipments.

A-11. [illegible], R. R., and R. C. [illegible], Economic Impact of Interstate Highway 35 on Blackwell, Oklahoma, Oklahoma State Highway Department, 1965. [illegible]

A study of the effects of I-35 on Blackwell, Oklahoma, using a control city comparison. Indicators include data on population, land use, employment and wages, sales tax, educational levels, postal receipts, and building permits.

A-12. Connally, Julia H., The Socio-Economic Impact of the Capital Beltway on Northern Virginia, Bureau of Population and Economic Research, University of Virginia, Charlottesville, Virginia, 1968.

A description of the types and intensities of development that occurred near Washington, D. C.'s Capital Beltway in Northern Virginia during 1960-1967. Changes in demographic, industrial, and land use characteristics are identified and related to the Beltway. Findings indicate that the Beltway increased [illegible] industrial and [illegible] development and associated land values. Single-family residential development was not influenced significantly, nor were the values of single-family homes. The author points out that the Beltway reinforced, rather than altered, the existing trend toward suburbanization.

A-13. Connally, J. A., and [illegible], "The Washington Capital Beltway and Its Impact on Industrial and Multi-Family Expansion in Virginia," Highway Research Record, Number 217, pp. 14-27, 1968.

An examination of industrial and multi-family development in Northern Virginia resulting from the Washington Capital Beltway. Findings include (1) that industrial employment increased by 71%, primarily because of new industry locations in the area; (2) that the beltway has altered commuting patterns; (3) that the beltway has enlarged the labor market; and (4) that 3,000 new apartment units were constructed between 1964 and 1966 due to the beltway. The pressure of increased traffic on interchange development is discussed, and land use controls are suggested.

A-14. [illegible], "The Evaluation of Travelling Time," Journal of Transport Economics and Policy, Vol. 3, No. 3, pp. 279-286, September 1969.

A summary of theoretical problems and of data problems in treating reduction of travel times brought about by investment in transportation.

A-15. Dansereau, H. Kirk, "Highway Development: Attitudes and Economic Climate," Highway Research Record, Number 187, pp. 12-42, 1967.

Four attitude surveys and four economic analyses pertaining to highway interchanges in various small communities in Pennsylvania. The economic analyses (land use and value within two miles of interchanges) indicate that highways generally stimulate economic growth; expected economic growth generates in turn favorable attitudes toward highway construction. A correlation between education level and recognition of the economic benefits of highways is suggested.

A-16. Deen, R. C., Impact of I-75 on the Local Economy between Walton and Georgetown, Kentucky Department of Highways, 1966.

Measurement of changes in business-oriented activity after the opening of an Interstate highway. Business activity along the old roads has decreased, but results indicate that the area's economy as a whole appears to have increased.

A-17. Dodge, W. H., Influence of a Major Highway Improvement upon an Agricultural-Based Economy, Wisconsin Department of Transportation, Division of Highways, and Wisconsin University, 1966.

A study of the impacts on the agricultural and trade economy resulting from a major highway improvement (I-94) in Dunn and St. Croix Counties, Wisconsin. The relief of congestion benefited long-haul traffic, local residents making longer trips, and use of parallel Route 12. It also spurred land reclassification, especially near larger communities. Lowered operating costs did not raise farm real estate values; however, as land reclassification affects productive land use, income and gross product are expected to increase.

A-18. Erion, G. L., and G. I. Mitchell, Effects of Highway Bypasses on Five Montana Communities, Montana University, 1966. NTIS (PB-170-871).

A study to determine the effects of bypasses on five small communities (population less than 5,000), and to test data availability for measuring these effects. The strength of local industry is viewed as an important determinant of bypass effects.

A-19. Fantus Company, Inc., "Industrial Location Research Studies: Summary and Recommendations," Appalachian Research Report, Number 4, December 1966.

An examination of why industry makes investments at particular locations with the objective of identifying types of infrastructure investments important in regional development. Selected measures of economic impact are discussed, and a ranking and evaluation of location factors considered important by firms in 25 industries are presented.

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An examination of input-output models to assess impact of highway investments on regional economic activity. Multiregional I/O models can be used to estimate stimulation of final demand and changes in trade patterns but not for assessing changes in costs of goods and services.

A-21. Faucett, Jack and Associates, Inc., Regional Economic Effects of Highway Investment - A Case Study of the Interstate System, Federal Highway Administration, July 1971.

An estimate of economic activity generated by Interstate highway construction in each of ten census regions. Benefits are based on estimated savings from

A-21. (Continued)

1957-1979 (separate congressional report) and are allocated to states by origin and destination of freight and passengers. A multi-regional input/output table is developed based on inter-industry transactions for each region considering interregional commodity flows.

A-22. Fidler, J., "Commercial Activity Location Model," Highway Research Record, Number 207, pp. 68-84, 1967.

A model to predict the most likely locations of future commercial activity in an urban area, designed to be a useful tool in transportation planning. A consumer demand is defined for commercial goods, and the movement of people to satisfy this demand is simulated. Model variables include: travel-time minimums; land use type; and family income.

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An analysis of development of highway-oriented business at 79 interchanges in nine states in eastern U.S. No clear relation with a number of independent variables (years since opening of interchange, distance to nearest city, population of nearest city) could be established.

A-24. Fromm, G., ed., Transport Investment and Economic Development, Brookings Institution, Washington, D. C., 1965.

A series of twelve articles concerned with the role of transportation investments in stimulating economic development. The focus is on normative design of national transportation policies to achieve pre-specified social and economic goals in undeveloped countries. The discussions cover policy strategies both for maximizing national outputs and for optimizing inter-regional distribution of economic and demographic activities. The articles range from purely theoretical to largely empirical, with the majority concentrating on theoretical aspects of economic development.

A-25. Gamble, H. B., D. L. Raphael, and O. H. Sauerlender, "Direct and Indirect Economic Impacts of Highway Interchange Development," Highway Research Record, Number 149, pp. 42-55, 1966.

A 54 sector input/output model of Clinton County, Pennsylvania to predict indirect economic effects of I-80 on this rural county. Primary economic impacts are estimated from a review of physical conditions at interchanges and from data for other Pennsylvania locations. An estimate is then generated for new facilities, relocation of existing facilities, and shifts in shopping patterns.

A-26. Garrison, William L., B. J. L. Berry, D. F. Marble, J. D. Nystuen, and R. L. Morrill, Studies of Highway Development and Geographic Change, University of Washington, Seattle, Washington, 1959.

A treatise on the role of highways in the geographical organization of economic life and of the influence of highway change. A general discussion of the role of transportation is followed by an analysis of the benefits of highway improvements. The spatial arrangement of retail business with respect to highways is then examined in detail. The influence of highways on residential site selection is treated both theoretically and empirically. The impact of highways on retail business is then re-examined with data on travel from residential sites. A final section treats in detail the relation of medical services to transportation.

A-27. Grossman, D. A., and M. R. Levin, "Area Development and Highway Transportation," Highway Research Record, Number 16, pp. 24-31, 1963.

A discussion of the general implications of new highways for three types of economically depressed areas (manufacturing, mining, or agriculture based economies) with particular emphasis on the Interstate Highway System. Highway impacts on mining and agriculture based regions (e.g., the Appalachian Region) appear to be small. Manufacturing-based areas, however, may be aided by industry relocation induced by improved accessibility and labor mobility (e.g., effect of Route 128 on Lowell and Lawrence, Massachusetts).

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A case study of the economic effects of a bypass highway on a rural county in Virginia. Impacts on a bypassed town of 5,500 people were analyzed using before and after and control area comparisons. Of three selected retail trades (gasoline, motels, restaurants), only gasoline stations appeared to have been adversely affected.

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A discussion of the spatial organization of the central business district (CBD) as defined by previous research in this field, and establishment of an analytical framework to evaluate change related to urban freeway development based on defined CBD "core" and "frame" areas. Measurement of CBD change (based on retail sales and office space trends during the post-World War II decade in 60 major cities) and decentralization (based on location changes in insurance, electrical utility, and banking services) are examined. A mail questionnaire survey of all state highway agencies was then conducted to define present and planned freeway development. Major common road types (radial, circumferential, and inner-distributor) and development patterns are identified from this data, and a preliminary discussion of freeway impact on the CBD is presented. An appendix reviews economic impact studies and discusses the tax structure as it relates to highway user and non-user benefits.

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An appraisal of the state-of-the-art of studies conducted prior to 1965 on economic impacts of highways. The largest volume of literature deals with effects of bypasses. No generalizations are possible on beneficial effects on bypassed communities; there is, however, conclusive evidence that bypasses affect communities differentially (substantially depreciate economic activity in one community and appreciate it in another). Urban radial freeway studies have shown that land values are materially enhanced by proximity to a radial corridor; however, most studies suffer from the bias of translating information about parcels sold into general conclusions for all land in their vicinity. There are few studies of circumferential roads; the most famous is the Route 128 study which showed a significant movement of industry to the vicinity of this highway.

A-31. Hooker, R. W., and K. R. Potter, The Impact of a New Interstate Highway on a Corridor: An Input-Output Analysis, Wyoming University, Federal Highway Administration, January 1971.

An input-output analysis technique to estimate the economic impact of Interstate Highway 80 on Southwestern Wyoming. Measurement variables are sales by local businesses, household income, and employment generated. Local coefficients are developed for a base year (1967); impacts are measured during construction (1965-1970), and forecasted for the period following highway completion (1970-1980).

A-32. Iowa State Highway Commission, Newton Economic Study, Interstate 80 Bypass, 1966. NTIS (PB-173-169).

A study of economic, land use, traffic, and highway safety effects of a bypass (I-80) in Newton, Iowa. It is concluded that the bypass has not deterred commercial growth, nor adversely affected the economy of the community as a whole.

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A report on the results of a nationwide survey of newly located business establishments between 1955 and 1959. The questionnaire survey sought to determine what factors were most important in plant location decisions for a variety of industrial classifications. The single most frequently mentioned factor was proximity to good highways, but market, labor, and land availability were also rated important. The relative importance of locational factors varies sharply from industry to industry. The results also reflect a pronounced outward movement of industry from central city to suburban and rural locations.

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An assessment of the relative importance of highway access to industrial firms through mailed questionnaires and in depth interviews. Firms were

A-34. (Continued)

grouped according to size (number of employees); type of decision (new firm or relocation); location (in or outside city); tenancy (owner or renter); and industry type (metal or non-metal). Highway access was most important to large firms relocating outside the city area.

A-35. Kraft, Gerald, et al., The Role of Transportation in Regional Economic Development, D. C. Heath & Company, Lexington, Massachusetts, 1971.

The authors examine the use of location theory and regional science to determine general highway transportation impacts on regional economic development.

A-36. Kuehn, John A., and J. G. West, "The Ozarks: Highways and Regional Development," Growth and Change: A Journal of Regional Development, Vol. 2, pp. 23-28, July 1971.

An overview of highway development in depressed areas and a contribution to the debate over whether highways should be the major focus in regional planning. Highway type is related to type and amount of industrial employment in the Ozark region. Major highways were not a crucial factor in explaining income variations or labor force characteristics; secondary and local roads showed a higher correlation with income.

A-37. Lane, D. R., Freeway Traffic Noise: An Information Base for Urban Development Decisions, 1972. NTIS (PB-[illegible]).

A profile of Los Angeles traffic volumes and residential densities is developed and general impacts of noise are described. Comparative critical data is used to identify noise "zones of intrusion" surrounding urban freeways. General connections between noise and urban economics and property values are made.

A-38. Leone, R. A., "Role of Data Availability in Intrametropolitan Workplace Location Studies," Annals of Economic and Social Measurement, Vol. 1, No. 2, pp. 171-182, April 1972.

A review of data base deficiencies in previous research on intrametropolitan location patterns, and presentation of a set of criteria for a new data base. Inter- and intra-city transportation requirements of each area establishment is proposed as one measure of location factors.

A-39. Leven, Charles L., "A Framework for the Evaluation of Secondary Impacts of Public Investments," American Journal of Agricultural Economics, Vol. 52, pp. 723-730, December 1970.

A discussion of approaches to secondary impact analysis. The "multi-dimensionality" of impacts is examined (e.g., some impacts can be quantified while others are qualitative, some impacts are positive while others are negative). The author questions the "stock-adjustment" response which he defines as meeting of a public service demand by increasing capacity (e.g., building a new highway) and advocates examination of reallocating

A-39. (Continued)

existing capacity (e.g., examine other modes of transportation for possible use).

A-40. Maiolo, John R., ed., Highways and Communities, Pennsylvania State University, Institute for Research on Land and Water Resources, University Park, Pa., 1966.

A review of five studies relating to Pennsylvania highway interchanges. Emphasis is on (1) predicting economic growth generated by interchanges; (2) land use plans to prevent future congestion of bypass intersections; and (3) social and community conditions conducive to (2). Two studies examine highway impacts in the towns of Blairsville and Monroeville, Pa. Other studies address: non-urban interchange development; dynamic simulation of land use at interchanges; and small community organization and its influence on land use planning.

A-41. Maryland State Roads Commission, Economic Impact Studies on a Portion of the Baltimore Beltway, July 1960.

A three-part coordinated land economic study to determine the overall effects of expressway construction on abutting residential subdivisions of the Towson section, north of the city of Baltimore. An examination of residential property sales data and the subjective responses of subdivision residents showed no significant beltway impacts.

A-42. Mason, J. B., and C. T. Moore, "Commercial Site Selection at Interstate Interchanges," Traffic Quarterly, Eno Foundation for Transportation, Vol. 27, No. 1, pp. 19-23, January 1973.

Summary of past research identifying the potential attractiveness of interchange areas to highway-oriented business. The authors conclude that development is most likely to occur at a diamond interchange which intersects either a U.S. or beltline highway, near an urban area of 25,000 or more population, with minimum average daily traffic of 7,500 vehicles. Additional criteria (e.g., water and sewerage system availability) are discussed, and additional research areas suggested.

A-43. McKain, Walter C., The Connecticut Turnpike - A Ribbon of Hope, University of Connecticut, Storrs Agricultural Experiment Station, 1965.

A before and after (1956-1962) study of the impacts of the eastern portion (53 miles) of the Connecticut Turnpike. Comparison of "turnpike" towns against "control" towns showed a relative increase of population, manufacturing, retail sales, and tourist trade. A higher annual appreciation of residential property was also found. Although the highway had a significant impact on economic growth, its effect was not as substantial as anticipated, primarily because of local opposition to change.

A-44. Meyer, J. R., J. F. Kain, and M. Wohl, The Urban Transportation Problem, Harvard University Press, Cambridge, Massachusetts, 1965.

An examination of urban transportation systems including highways and mass transit. The focus is on the effect of transportation on the overall metropolitan environment.

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A-45. Michigan State University, Economic and Social Effects of Highway Improvements: A Summary, summarized by E. Clare Bowley, East Lansing, Michigan, 1961.

A summary and evaluations of the findings of seven studies of highway impacts carried out in the late 1950's in small to medium sized towns in Michigan. Economic impacts and induced community changes are examined for three separate kinds of highway investments: relocations, bypasses, and improved regional highway networks. Highway-related impacts include changes in land values, retail trade, population growth, and land use patterns. Highway relocations and bypasses did not significantly decrease business activities along the old routes. However, both property values and land usage along the old and new routes were affected.

A-46. Mills, E. S., Studies in the Structure of the Urban Economy, Resources for the Future, Inc., 151 pp., 1972.

An empirical study of the patterns and causes of suburbanization from the 1880's to the 1960's. Theoretical models are constructed to analyze the relation between location of employment and residence in urban areas. Congestion as a cause and effect of suburbanization is examined, as well as ways in which investment and pricing in urban transportation can affect urban residential density.

A-47. Missouri State Highway Commission, Boonville Economic Study, 1958-1963, 1965 NTIS (PB-172-983).

Analysis of the economic effects of a bypass highway (opened in 1960) on Boonville, Missouri. Three new interchange areas are also examined. Retail sales of gasoline, hotel and motel, restaurants, and general merchandise are examined from 1958 to 1963.

A-48. Montana State College, Benefits from Highway Development: User and Non-User, Agricultural Experiment Station, Bozeman, Montana, 1956.

User and non-user benefits in two areas along secondary roads in Montana are examined. Highway beneficiaries include highway (motor vehicle) users; property owners; the general public; and the automotive industry.

A-49. Moore, C. T., A Study of the Expected Economic and Social Impact of Interstate Highways in the Industrial and Commercial Trading Area of Birmingham, Alabama, Alabama Highway Department, Final Report, September 1965.

An examination of possible impacts resulting from completion of the Interstate Highway System in Birmingham, Alabama. Portions of the system completed by 1965 in outlying rural areas encouraged movement of people and goods away from the CBD. Impact areas addressed include: manufacturing; retail trade and service industries; transient-oriented businesses; land use; and social impacts. Ways in which the CBD might remain competitive with outlying areas are suggested (e.g., development of service industries, cultural activities, etc.).

A-50. Mueller, Eva, A. Wilken, and M. Wood, Location Decisions and Industrial Mobility in Michigan, University of Michigan, Institute for Social Research, 1961.

An exploration of industrial attitudes toward location decisions (including new locations, plant expansion, and relocation) among Michigan manufacturers in 1961. The authors' objective was to assess Michigan's attractiveness for industry as measured by satisfaction or dissatisfaction with specific area characteristics. Among factors considered important in plant location decisions were access to markets and access to materials (including transportation costs). Traffic access and parking as such did not rate high in a list of twenty-one possible responses.

A-51. North Carolina State Highway Commission, Remainder and Economic Study at Interchanges on I-95, North Carolina State Highway Commission Research Project, Raleigh, N. C., 1966.

An examination of 36 interchanges on I-95, extending in a general north-south direction through North Carolina. A field investigation of each interchange was conducted to determine sales and leases and amount and type of development. Interchange classifications included: full (ramps leading to four quadrants); partial (ramps leading to 1, 2, or 3 quadrants); and terminal (the termination points of the Interstate highway). The dependence of development on interchange and type quadrant was examined: no clear patterns were evident.

A-52. North Star Research and Development Institute, The Economic Impact of the Freeways on the Twin Cities Metropolitan Area, Minneapolis, Minnesota, 1971.

An examination of six impacts (land use, retail trade, residential property values, tax patterns, commercial and industrial freight, and community changes) of three Interstate segments of the Twin Cities' Freeway System. The highways examined include radial and circumferential freeways; were constructed from 1960 to 1968; and traverse both urban and suburban areas.

A-53. Ohio Department of Highways, A Bypass Economic Impact Study of Circleville, Piqua, and St. Clairsville, Ohio, May 1966.

An examination of the economic effects of bypass highways in three cities with population levels of approximately 19,000, 11,000 and 4,000. Industry was disaggregated into eleven groups for study. Gasoline sales decreased in all cities and most stations compensated by increasing repair and service functions. The smallest city (St. Clairsville) showed the greatest decrease, and the least ability to recover. Motels in all cities were adversely affected by bypass construction.

A-54. Oklahoma Department of Highways, Economic Impact of Interstate Highway 35 on Tonkawa, Oklahoma, U.S. Bureau of Public Roads, 1968.

An interim report describing impacts of Interstate Highway 35 on Kay County based on before and after comparison, and comparison to a control county (Woodward County). Variables examined include: land use, population, employment, wages, education, income, sales tax, and agricultural production. Interstate 35 was completed in January 1963. In the following two years, sales taxes increased by 11.3% in the study area (approximately twice that of the control area); gasoline station sales declined 5.8%; and sales of commercial land doubled.

A-55. Pennsylvania State University, Highway Impact Research Staff, Blairsville: A Bypass Study - The Economic and Social Impact of a Highway, 1962.

Effects on business activity and land use caused by the construction of an uncontrolled access highway bypass of a rural Pennsylvania town during the 1950's. Data was collected through interviews and mailed questionnaires. Changes were measured in the CBD, along the new highway, and along the old road. Impact analysis includes: business type and level, land use, and land value. The study concludes that diversion of through traffic allowed more extensive use of the CBD for local trade.

A-56. Pipkin, L. S., F. L. Hendrix, and G. L. Banner, Economic Impact of Interstate 40 on Existing Development Along State Route 1 Between Knoxville and Kingston, Tennessee, and Adjacent Areas, Tennessee University, 1966.

Examination of business activity, land use, and land value along Route 1 after the construction of I-40 in Tennessee. A sharp decline in business was observed the first year following road opening. Other non-highway change factors are noted, such as: service facility availability; age and location of business. In land use, topography, drainage, lack of accessibility, and reluctance of people to move from family holdings were significant factors.

A-57. Rae, J. B., "The Mythology of Urban Transportation," Traffic Quarterly, Eno Foundation for Transportation, Vol. 26, No. 1, pp. 85-98, January 1972.

A discussion of the historical and functional bases for the development of urban centers, and increasing suburbanization trends. The author contends that urban transportation planning should stress intersuburban travel, rather than focus solely on peak-hour commuter travel between suburb and city center.

A-58. Rapp, John, Economic Impact Study of U.S. 81 through Yankton, South Dakota. Prepared for South Dakota Dept. of Highways, Research and Planning Division, November 1966.

An examination of economic and social effects of highway improvements along a 3.1 mile section of U.S. 81 in Yankton, S. D. from 1956-1966. Changes in land use, assessed valuations, land values and property tax payments, sales and employment, and sociological benefits were estimated using before and after and control area comparisons. Substantial increases in land value, land use conversion to commercial uses, number of businesses, and employment and sales were found. Benefit-cost analysis showed a 6:1 ratio.

A-59. Real Estate Research Corporation, Highway Networks as a Factor in the Selection of Commercial and Industrial Locations, prepared for the U.S. Bureau of Public Roads, U.S. Department of Commerce, 1958.

Results of a survey (134 newly-located businesses in the Chicago, Pittsburgh, and Hartford areas during the 1950's) designed to determine the importance of highway networks in corporate location decisions. Businesses consider a number of factors in their location decisions; highway-related factors seldom dominate. The importance of highway factors varies widely for different types of industry.

A-60. Reinsburg, Mark, *Growth and Change in Metropolitan Areas and Their Relation to Metropolitan Transportation*, Northwestern University, Transportation Center, Evanston, Illinois, 1961.

A discussion of the roles of mass transit and automobile transportation in the decline of the central business district (CBD). Congestion of the inner city because of increased automobile use, migration of higher income families to the suburbs, migration of industry from the CBD, and a reduced tax base in the inner city are noted. The declining use of mass transit, the possibility of subsidy for mass transit, and the role of the CBD as a "seed bed" for new small firms are discussed. It is suggested that survival of urban mass transit in its present form is unlikely.

A-61. Richards, H. A., J. P. Miller, and W. H. Allio, *A Study of Interstate Highways, Frontage Roads, and Industry Location*, Texas Transportation Institute, Texas A & M University, 1968. NTIS (PB-180-351).

A review of studies dealing with industrial plant location, in relation to the Interstate Highway System (with and without frontage roads) in Texas. Findings included: (1) firms locating after highway completion consider frontage roads more important than those located prior to completion; (2) that firms near metropolitan areas valued frontage more than in smaller communities; and (3) that leased plants tend to be oriented toward frontage road areas.

A-62. Shurbert, M., and F. J. Devaney, "Maryland Capital Beltway Study," *Highway Research Record*, Number 277, p. 41, 1969.

A summary of the design of an impact study of Interstate 495 (Capital Beltway) on Montgomery and Prince Georges Counties.

A-63. Smith, Wilbur & Associates, Inc., *Maryland Capital Beltway Impact Study: Final Report, Washington SMSA and Maryland Counties*, prepared for the Maryland State Roads Commission, June 1968.

An analysis of the impact of the Capital Beltway on the Washington SMSA in the areas of: economic base; industry; recreation; institutional development; work trips; business centers; residential property values; population allocation; employment; retail sales; labor force, housing units and automobiles; traffic noise; and traffic. While the study area includes the entire Washington SMSA, main emphasis is given to the Maryland Counties of Montgomery and Prince Georges. A variety of methodologies is used to trace the impacts from the opening of the beltway in 1964 to the completion of the study in 1968. Historical trends are analyzed from 1950 to provide a base for assessing impacts.

A-64. Straszheim, Mahlon R., "Transportation Policy as an Instrument for Altering Regional Development Patterns -- Misdirected Emphasis?," *Discussion Paper Number 52*, Harvard University Program on Regional and Urban Economics, Cambridge, Mass., August 1969.

An analysis of the historical role of transportation in regional development. The growing service industry, metropolitan decentralization, and the decreasing dependence on proximity to raw materials have contributed to a decline in the importance of regional transportation systems. In addition, more homogeneous

A-64. (Continued)

transportation throughout the country has lessened the significance of new investments. The evolution of study techniques from classical location theory to large scale simulation models is summarized.

A-65. Stroup, R. H., and L. A. Vargha, "Economic Impact of Secondary Road Improvements," *Highway Research Record*, Number 16, 1963.

An analysis of the changes in retail trade (location and markets) resulting from improvements to secondary roads in a rural town in Kentucky. Businesses which closed or opened from 1938-1950 and 1955-1960 were examined. Data indicated that paving of secondary roads stimulates concentration of retail business in areas made accessible by these roads.

A-66. Wells, D. R., *An Economic Impact Study of the Effects of Interstate 55 on the Highway-Related Businesses in Five Northern Mississippi Towns*, Mississippi University, Mississippi State Highway Department, June 1967.

Effects of a bypass on total sales of eating and lodging places and sales of gasoline by service stations. Although aggregate figures show little impact, some firms were adversely affected.

A-67. Wheat, L. F., "Effect of Modern Highways on Urban Manufacturing Growth," *Highway Research Record*, Number 277, 1969.

An attempt to determine whether cities with superior intercity highway connections enjoy more rapid manufacturing industry growth. Manufacturing growth rates from 1958 to 1963 are compared for two groups of cities, an experimental group located on Interstate System freeways, and a control group located elsewhere. The two groups were comparable in all major aspects -- population, location, air service, economic activity, etc. -- except highways. Nationwide, there was no significant difference in the growth performance of the two groups. But in areas with dense populations and uneven terrain -- the Northeast, Southeast, East Midwest, and Far West -- freeway cities grew much faster.

A-68. Whitehurst, C. H., *The Road Around: A Study of the Economic Impact of Highway Bypasses on Rural South Carolina Cities and Towns*, Clemson University, 1965. NTIS (PB-172-938).

A case study to evaluate bypass highway impact on five small cities and towns (under 10,000 population) in South Carolina. Field interviews and analysis and comparison of land value data indicated that: (1) highway-oriented business sales may decrease in a high-growth town, but overall community growth will offset these losses; (2) low-growth towns will experience more adverse effects on highway-oriented growth; and (3) businesses tend to cluster around bypass intersections with main highways, while residential land use will locate between main artery intersections.

A-69. Williams, R. L., and R. K. Koshal, *Highways and Economic Development in Ohio, Volume 1*, Ohio University, Ohio Department of Public Works, Athens, Ohio, 1970.

The impact of highways on economic growth in all 88 counties of Ohio measured empirically from growth of per capita income (as deduced from sales taxes). It is concluded that highways induced growth although the relation between highway capacity and income level varied widely from county to county.

A-70. Witheford, David K., "Highway Impacts on Downtown and Suburban Shopping," *Highway Research Record*, Number 187, pp. 15-20, 1967.

An assessment of the highway role in the growth of suburban shopping retail sales centers and the relative decline of trade in the central business district. Market areas within equal travel times of each shopping area are compared and reassessed after a metropolitan transportation improvement program increases the equal travel time radii by a constant amount. Buffalo, New York is used as a test case. The analysis shows that highway improvements favor suburban shopping areas.

A-71. Wright, A. L., and M. G. Blase, "A Depressed Region and Three Myths," *Growth and Change: A Journal of Regional Development*, Vol. 2, pp. 14-22, July 1971.

An overview of highway development in depressed areas and a contribution to the debate on the role of highways in regional planning. Multiple, cross-sectional regression analysis is used to relate a major arterial highway serving the Missouri Ozark region to per capita income growth and types of employment during 1950-1965. The study challenges the assertion that opening up of depressed areas through Interstate highways leads to increased participation in national growth.

A-72. Wullweber, L. D., *South Dakota Interstate Highway 29, Economic Impact Study*, South Dakota Department of Highways, June 1967.

Analysis of the effect of a bypass on four towns as measured by changes in taxable retail sales. Although the area as a whole benefited by the new highway (Interstate 29), certain areas and business located on the old road (U.S. 77) were adversely affected.

A-73. Wullweber, L. D., *Long Term Economic Effects of Highway SD 50 Bypass on Tyndall, South Dakota*, South Dakota Department of Highways, 1967.

An examination of changes in business sales, traffic volume, and highway safety in a small town (Tyndall, South Dakota) resulting from a bypass highway. Sales for the town as a whole were not affected by the bypass route.

A-74. Zickefoose, P. W., *Raton Bypass Study - After Phase*, New Mexico State University, November 1967.

A study of the impact of a bypass on the Raton community, six years after highway completion. Examination of tourism, transient-oriented business sales, and land use changes lead to the author's conclusion that the bypass

A-74. (Continued)

has not produced the economic boost anticipated by bypass proponents, nor the disasterous business decline predicted by bypass opponents.

A-75. Zwick, Charles J., "The Demand for Transportation Services in a Growing Economy," Highway Research Record, Number 2, pp. 3-5, 1965.

Causal relations between transportation and economic growth and how they have changed over time. It is suggested that transportation shaped economic growth in the past, but that today forces exogenous to the transportation system determine economic development. Mobility of labor and capital and increasing dominance of these two factors over raw material inputs in industry allow industry to locate near its markets rather than near raw materials. Rising personal income has led to willingness to pay for quality in transportation service. Future transportation systems will be determined by economic forces and demands for quality service.

I. HIGHWAYS

B. Social-Demographic

B-01. Ashford, N. and F. W. Halloway, The Effect of Age on Urban Travel Behavior (Report No. 1), Florida State University Transportation Center, June 1970. NTIS (PB-196-843).

A quantitative analysis of the effect of age on urban travel, using six cities of varying geographic location and population size for case study. Travel parameters (3 modes of transportation; 5 trip purposes) were correlated with socio-economic variables by regression models. Large variations in travel behavior and demand among age levels are indicated.

B-02. Balkus, K., "Transportation Implications of Alternative Sketch Plans," Highway Research Record, Number 180, pp. 52-70, 1967.

An analysis of three patterns of possible regional growth (decentralized, new-town, and megalopolis), and a discussion of how a transportation network can be designed to influence these population distribution patterns. Two travel characteristics -- propensity for making trips, and relative utilization of transport modes -- are correlated with population distribution patterns.

B-03. Buffington, J. L., D. Burke, W. Adkins and H. Meuth, Experience and Opinions of Residents Along Elevated, Depressed, and On-Grade Freeway Sections in Houston, Texas - Economic & Environmental Effects as Factors in Highway Decision Making, Texas Transportation Institute, Texas Highway Department, Federal Highway Administration, Report No. 2-1-71-148.

A survey of residents near the Katy Freeway in Houston, Texas (opened in 1968) to determine impacts and reactions to highway location and design. Respondents (primarily white males, approximately 48 years old, 9 years formal education, middle income, single-family dwelling units) indicated satisfaction with improved accessibility. Noise was the most frequent annoyance factor mentioned (less significant in depressed freeway design areas).

B-04. Burkhardt, J. E., "Impact of Highways on Urban Neighborhoods: A Model of Social Change," Highway Research Record, Number 356, pp. 85-94, 1971.

A model to estimate changes in social interaction in urban neighborhoods caused by highway improvements. Residents' behavioral and perceptual patterns provide the basis for a "neighborhood social interaction index." The influence of highways on this index is measured by: amount of land taken; and placement of the highway with respect to the spatial dispersion of social factors. Number of crossovers per mile and roadway elevation are used in addition to measure intra-neighborhood accessibility changes.

B-05. Christensen, A. G. and A. N. Jackson, "Problems of Relocation in a Major City: Activities and Achievements in Baltimore, Maryland," *Highway Research Record*, Number 277, pp. 1-8, 1969.

A discussion of the problems with relocation assistance for those displaced by highways and a description of relocation activities in Baltimore.

B-06. Clawson, Marion, "Implications of Recreational Needs for Highway Improvement," *Highway Research Board*, Bulletin 311, pp. 31-37, 1962.

A discussion of the possible effects of highways providing access to three types of recreation areas: user-oriented (close availability to user group); resource-based (abundant natural resources); and intermediate areas (within one-hour travel time and the best natural areas available). Outdoor recreation growth is assumed to be the result of increases in population, per capita income, leisure time, and accessibility. An index of national outdoor recreation for 1956-2000 is presented, based on these four factors.

B-07. Cooper, E., *Methods of Improving Transportation Facilities for Inner-City Dwellers*, Howard University, 1970. NTIS (PB-194-095).

An examination of methods for providing transportation services to inner-city residents and equality of access to employment, recreational, and other urban opportunities. Proposed case studies in Washington, Nashville, and New York will test the results of a previous study of New York City low-income residents on origin-destination; car ownership; and access to opportunities. The author contends that integrated planning of transportation and urban development is necessary; and that the government should assist inner-city dwellers in achieving mobility (e.g., subsidization of private personal vehicles).

B-08. Dansereau, H. Kirk, "Five Years of Highway Research: A Sociological Perspective," *Highway Research Record*, Number 75, pp. 76-82, 1965.

A summary of some social impacts (income, employment, migration, community outlook, and organization) identified by Pennsylvania State University researchers in impact studies conducted on various types of interstate highways.

B-09. Dansereau, H. Kirk, "Highway Development: Community Attitudes and Organization," *Highway Research Record*, Number 16, pp. 44-59, 1963.

An analysis of social characteristics, attitudes, and community complexity in three communities within the Pittsburgh SMSA affected by the introduction of infrequent access radial highways and/or circumferential highways. Attitude toward highway improvements were obtained from primary field surveys. Generally, there was satisfaction with social and economic changes resulting from the highway. An 11-variable "Index of Community Complexity" was developed to record how communities respond to a highway investment (e.g., land subdivision controls, establishment of a sewer authority, zoning commission activities).

B-10. Ehrlich, T., *Specialized Trip Distribution Study: Metropolitan Recreation*, Consortium of University, Urban Transportation Center, 1970. NTIS (PB-194-096).

Model development to estimate demand for recreational facilities. Demographic and land use data from the regional council of governments was combined with results of a license plate survey of a recreation area (residential origins determined from motor vehicle registration data) to compute park visitation in terms of: (1) user's residential area; and (2) travel time.

B-11. Ellis, R. H. and R. D. Worrall, "Toward Measurement of Community Impact: The Utilization of Longitudinal Travel Data to Define Residential Linkages," *Highway Research Record*, Number 277, pp. 25-39, 1969.

A method for empirically defining existing residential linkages involving the analysis of activities of households and of the important set of destination points as perceived by households. Data and analysis are presented for Skokie, Illinois. The approach can be used to estimate the community impact of transportation projects.

B-12. Falcocchio, J., *Modal Choices and Travel Attributes of the Inner-City Poor*, Polytechnic Institute Brooklyn, September 1971. NTIS (PB-206-149).

A profile of inner city residents and their travel habits. Residents are disaggregated by race, age, household size, median income, occupation, automobile ownership, trips per household, trip purpose, and modal split. Data show that most inner city residents travel less, have less modal choice, less mobility and reduced opportunities for all trip purposes.

B-13. George, Stephen, Jr., "Transportation System Development and Evaluation as Practiced in Seattle," *Highway Research Record*, Number 238, pp. 116-122, 1968.

Evaluation of the Puget Sound (Seattle, Washington) transportation system, using population distribution and employment distribution models. It is suggested that residential characteristics (e.g., quality of homes) are becoming more important than access to employment; that added transportation capacity may be needed in the suburbs rather than the central business district; and that with a given mileage of committed major facilities and an established travel pattern, land use planning should conform and strengthen major travel corridors.

B-14. Goodwin, A., "Attitudes and Shopper Mobility in a Small City," *Highway Research Record*, Number 233, pp. 16-26, 1968.

A comparison of shopper attitudes in small (less than 50,000 population) and large cities, to analyze the decentralization of retail trade from the CBD to suburban areas. Inadequate parking was cited as the major disadvantage of the CBD in both large and small cities. Small city CBD shoppers tended to be older, persons of modest means, or in the upper income levels. Suburban shoppers were generally in the middle groups in terms of age, education, income, and family composition characteristics. A group of shoppers indicating high mobility was composed of younger, higher income, and white collar employed persons.

B-15. Greytak, D., Residential Segregation, Metropolitan Decentralization and the Journey to Work - Occasional Paper No. 3, Syracuse University, Urban Transporation Institute, July 1970. NTIS (PB-196-904).

An examination of the spatial redistribution of trade and manufacturing activities in urban areas. The concentration of professional jobs in the CBD and the migration of the skilled labor force to suburban residences; and the concentration of non-white residences in the central cities while unskilled manufacturing and trade job opportunities move away from the central city are discussed, and housing segregation is viewed as a significant factor in shaping these trends.

B-16. Grier, George W., "Social Impact Analysis of an Urban Freeway System," Highway Research Record, Number 305, pp. 63-74, 1970.

A social impact analysis of a proposed highway network in Baltimore, Maryland, consisting of four radial highways (three of them part of the Interstate Highway System). Social characteristics of Baltimore are discussed (large outmigration of whites in the 25 to 64 age levels; an increasing percentage of blacks in the city population). As a result of the social impact analyses, the plans were altered to minimize or avoid predicted social problems.

B-17. Hinshaw, M. and K. Allott, "Environmental Preferences of Future Housing Consumers," Journal of the American Institute of Planners, Vol. 38, No. 2, March 1972, pp. 102-107.

A housing and neighborhood preference survey of urban youths, with the results disaggregated according to race/ethnicity, family income level, and type of housing presently occupied. Housing preferences, throughout almost all groups, were for single-family suburban homes, with little desire for proximity to relatives. Neighborhood preferences were ranked according to importance: "... overall, safety and proximity to good schools are considered to be critically important. Attractiveness, proximity to transit stops, friendliness of neighbors, and access to parks are considered important or very important as decisional factors, while proximity to shops, entertainment, and place of work are considered relatively unimportant."

B-18. Hyman, G. M., "Trip Distribution and Modal Split by Categories of Households," Transportation Research, Vol. 4, No. 1, pp. 71-76, April 1970.

An analysis of the dependence of trip generation on the distribution of household variables (e.g., income, car ownership). Modal splits depend on household categories.

B-19. Kalachek, E. D. and J. M. Goering, Transportation and Central City Unemployment, Washington University, St. Louis, March 1970. NTIS (PB-192-493).

A refutation of the theory that lack of adequate transportation deprives inner city residents of the mobility required to obtain jobs. The study includes data for St. Louis on location of employment and residences in 1960; job hunting patterns; job tenure; and a survey of suburban manufacturing plants.

B-20. Kanwit, Edmond L. and A. F. Eckartt, "Transportation Implications of Employment Trends in Central Cities and Suburbs," Highway Research Record, No. 187, pp. 1-14, 1967.

Describes employment trends in 24 largest SMSA's of U.S. during 1948-63 and analyzes the volume and proportion of employment in the central cities and suburbs. Shows rapid growth in suburbs and progressive relative decline in central cities.

B-21. Koike, H., Planning Urban Transportation Systems: A Model for Generating Socially Desirable Transportation Network Configurations - Research Report No. 2, Washington University, Seattle Urban Planning and Civil Engr. Departments. NTIS (PB-199-290).

A model for designing transportation networks to increase the "satisfaction level" - an index depending on transportation accessibility, employment accessibility and socio-economic status. A weighing function favors least satisfied residents in an urban area.

B-22. Kurkhardt, J. E. and M. T. Shaffer, "Social and Psychological Impacts of Transportation Improvements," Transportation (NETH), Vol. 1, No. 2, pp. 207-26, August 1972.

A discussion of the social impacts of transportation improvements in urban neighborhoods. The identification of social impacts, suggested measurement techniques, and the need for transportation planners to consider these impacts in the planning process are presented.

B-23. Lisco, T. E., "Value of Commuters Travel Time - A Study in Urban Transportation," Highway Research Record, Number 245, p. 36, 1968.

A modal choice study based on household interview data collected as part of the Chicago Skokie Swift Mass Transportation Demonstration Project. Analysis of times and costs for alternative trip modes inferred by choices of commuters, and the effects of commuter characteristics (e.g., income) on modal choice was conducted. Results showed that: (1) typical commuters value time at 4 or 5 cents per minute, and value comfort at $2.00 per day; (2) that commuters will choose between transit and automobile travel based on time and cost benefits; and (3) the discomfort of walking time is significant (an indication that placement of transit stations may be important in determining use).

B-24. Manarolla, J. A., The Trip to Work - A Submodule of a General Metropolitan-Regional Area Man-Machine Simulation, Consortium of University, Urban Transportation Center, 1970. NTIS (PB-194-099).

A general operational simulation of a metropolitan or regional area. Variables include spatial relations, private economic activities, local government functions, and federal/state aid, and personal functions (job seeking, demand for public facilities, leisure time activities, voting behavior). A gaming situation is used to assess travel time, convenience, and costs in determining modal choice for journeys to work.

B-25. McKain, W. C., "Community Response to Highway Improvements," Highway Research Record, Number 96, pp. 19-23, 1965.

An examination of community capacity for change as an important factor in highway impact, with specific reference to the Connecticut Turnpike's influence

B-25. (Continued)

on Eastern Connecticut. The area is rural with many small towns; its labor force is characterized by little education, narrow skills (making retraining difficult), and little propensity to migrate. The author contends that local governments were unable to respond to opportunities presented by the turnpike because their constituencies opposed change.

B-26. McLean, E. L. and W. G. Adkins, "Freeway Effects on Residential Mobility in Metropolitan Neighborhoods," Highway Research Record, Number 356, pp. 95-104, 1971.

A summary of research to: delineate metropolitan neighborhoods, assess freeway impact on residential mobility, and create a causal and predictive analysis framework. Study of 152 neighborhoods (bordering or segmented by a freeway) and 47 control neighborhoods (not bordering a freeway) are examined in Austin, Dallas, and Houston; a "neighborhood" index (to measure neighborhood delineation and residential socio-economic level) and a "mobility" index (to measure residential mobility) are developed and tested.

B-27. Meyburg, A. H., "Analysis of Relationships Between Intercity Passenger Transportation and the Socio-economic Characteristics of Metropolitan Areas," Transportation Research Forum, Vol. 13, No. 1, pp. 271-84, 1972.

Development of measures of socio-economic characteristics of metropolitan areas, with specific reference to intercity transportation system characteristics. Forty metropolitan areas in the Northeast Corridor are analyzed over a 30-year period, and the significance and stability of statistical relationships are examined.

B-28. Mouchahoir, G. E., The Relationship of Work Trips to Employment Connected Social and Economic Factors, 1970. NTIS (PB-197-816).

An analysis of socio-economic and travel variables as exhibited by the employees of 20 large Atlanta work centers making trips to work. Trip variables were correlated with square footage of work centers; average occupational level; and distance of employee travel. A model is developed having causal and functional characteristics which permit analysis of existing conditions, and calibration of forecasting techniques.

B-29. Mouchahoir, G. E. and P. H. Wright, "Use of Socioeconomic Indicators in Trip Attraction of Large Work Centers," Highway Research Record, Number 392, 139-42, 1972.

Design of a trip-attraction model for large work centers, based on a mail survey of 25,000 employees in 25 Atlanta work centers. Indicators were obtained for employers (floor space, distance from Atlanta CBD, assessed value of work center, and number of work trips attracted); and employees (including occupation, education, incomes, age, years at work, travel time and distance, home value, number of cars, number of children).

B-30. Nash, W. and J. Voss, "Analyzing the Socio-Economic Impact of Urban Highways," Highway Research Board, Bulletin 268, pp. 80-94, 1960.

A study of physical impacts (e.g., displacement of families) and "functional" impacts (e.g., population, employment) of the metropolitan highway system on

B-30. (Continued)

Boston, Massachusetts and outlying communities. A methodology is suggested for assessing functional impacts of highway development places. Impacts are discussed in terms of income, employment, journey to work, population growth and distribution, land densities and development, recreation, and taxes.

B-31. Redding, M. J. and G. L. Peterson, "Adequacy of the Spatial Organization of Residential Neighborhoods: The Residents' Point of View," Highway Research Record, Number 410, pp. 64-65, 1972.

A model is developed to determine resident preferences for accessibility to selected neighborhood services. The desire for access is weighed against aversion to proximity to determine residential preference.

B-32. Ryan, C. R., et al., "An Evaluation of the Feasibility of Social Diagnostic Techniques in the Transportation Planning Process," Highway Research Record, Number 410, pp. 8-23, 1972.

A social diagnostic survey of residents near Milwaukee and Wauwatosa, Wisconsin who would be affected by a highway extension. Demographic characteristics (race, age, income, education levels, home ownership, and organization affiliations) developed from a questionnaire survey were correlated with attitudes toward existing and proposed transportation services. Respondents were equally divided (pro and con) concerning the proposed project. Age was the most significant variable, since those 60 years or older tended to oppose the project, while those in the 20 to 40 year age group indicated approval of the plans.

B-33. Sawhill, Roy, Freeways and Residential Neighborhoods, Automotive Safety Foundation, Washington, D.C., 1965.

An examination of a freeway crossing the North Broadway area of Seattle, dividing it into three parts, and demolishing existing urban structures (e.g., churches and schools). Impact analysis includes: land use (residential and commercial development and rezoning); and household characteristics (school commuting, traffic congestion, use of highway for shopping and personal business, property values, dislocations).

B-34. Sinha, K. C., "Reliability Analysis in Land Use-Transportation Planning," Highway Research Record, Number 392, pp. 157-158, 1972.

Development of a method for estimating future design-year population levels for use in the land use-transportation planning process (e.g., for predicting ridership demand on transit systems, or traffic volume on a planned highway network). Seven counties in southwestern Wisconsin are studied and future design-year populations estimated.

B-35. Skidmore, Owings & Merrill, Center City Transportation Project: Urban Design Guideline, September 1970. NTIS (PB-198-600).

Case studies of five cities (Denver, Dallas, Atlanta, Pittsburgh, Seattle) including evaluation of urban design work programs, and a field survey of

B-35. (Continued)

communities in each area. Three levels of urban design are addressed: (1) city form; (2) transportation architecture; and (3) human factors.

B-36. Smith, Wilbur & Associates, Inc., The Impact of Highways on Selected Public Services, Prepared for the U.S. Department of Commerce, Bureau of Public Roads, New Haven, Connecticut, 1960.

An attempt to identify the beneficial effects of highways on seven selected public services by examining national trends and several state and city areas from the early 1900's through 1958. Impacts and measurement variables included: public education (number of students, daily attendance, number of school districts, student commuting distance); health (accessibility to rural areas, mobile clinics, patient travel distance, emergency services); postal service (number of postal districts, transport and delivery routes and cost); library services (circulation, bookmobiles, branch libraries); police protection (additional demands for traffic services, manpower, state and local police forces); fire protection (number of fires, accessibility); and location of public facilities for the above services. It is suggested that increased accessibility provided by highways has been a major contributing factor to the revolutionary changes observed in all these areas in the last fifty years.

B-37. Stegman, Michael, "Accessibility Models and Residential Location," Journal of the American Institute of Planners, Vol. 37, No. 2, March 1971, pp. 100-110.

A national survey of reasons for household location indicating that the most frequently cited cause is a desire for more space. Other causes, in order of frequency, are: desire to own a home; forced moves; desire for a lower-cost alternative; improved housing quality; improved neighborhood quality; move to a location more accessible to a job.

B-38. Thiel, Floyd, Allocating Social Costs of Highway Transportation, Prepared for Use at the Sixth U.S.-Japan Transportation Research Panel Meeting in Tokyo, May 15-16, 1973.

A discussion of the social costs (monetary and other) of highways experienced by individuals relocated from highway right-of-way; individuals abutting highways; and neighborhoods. Other social costs examined include land or space used, poor mobility of those without cars, billboards or junkyards along highways, and accident and control expenses. The author suggests methods to minimize such costs (e.g., increased land acquisition near highways, increased community planning and participation).

B-39. Thiel, Floyd, "Indirect Effects of Highway Improvement," Highway Research Record, Number 327, 1962.

A summary and overview of social and economic impacts of new highways and highway improvements, primarily in metropolitan areas. Ten impact areas are addressed generally: suburbanization, population mobility, residents' attitudes, employment, public services, church activities, rural areas, recreation, relocation, and transient services.

B-40. Thomas, T. C., G. I. Thompson, T. E. Lisco and P. R. Stopher, "The Value of Time for Commuting Motorists as a Function of Their Income Level and Amount of Time Saved," Highway Research Record, Number 314, pp. 1-19, 1970.

An analysis of data collected by Stanford Research Institute to estimate the value of travel time saved for commuting motorists as a function of their income level and the amount of time saved.

B-41. Thomas, T. C., G. I. Thompson, and S. Reichman, "Value of Time Saved by Trip Purpose with Discussion and Closure," Highway Research Record, Number 369, pp. 104-117, 1971.

A model to determine route and motorist characteristic variables having an effect on the valuation of travel-time savings by motorists. Several trip types are examined (personal, socio-recreational, vacation, school, and work trips). Data included more than 4,000 responses in nine states from motorists choosing between a toll route or a free route. Time saved and income were the most important variables, though these differ in importance for each trip purpose studied.

B-42. Ueberschaer, M. H., "Choice of Routes on Urban Networks for the Journey to Work," Highway Research Record, Number 369, pp. 228-238, 1971.

Description of a trip diversion model based on four factors (travel time, distance, number of possible stops, and maximum lane volume). Factors were derived from 13,000 driver interviews to determine daily route choice.

B-43. Wachs, Martin, "Basic Approaches to the Measurement of Community Values," Highway Research Record, Number 305, 1970.

A discussion of measurements of community values in urban transportation. Four basic techniques are suggested: 1) monitor individual behavior toward the existing transportation systems, and infer a value structure from this behavior; 2) monitor individual behavior in a gaming situation; 3) conduct opinion surveys on existing transportation systems; and 4) survey opinions and preferences toward a hypothetical transportation system.

B-44. Watson, P. L., "Problems Associated with the Time and Cost Data Used in Travel Choice Modeling and Valuation of Time," Highway Research Record, Number 369, pp. 148-158, 1971.

Two hypotheses regarding model calibration are evaluated: 1) that choice of travel mode relates to times and costs of the journey as perceived by the traveler; and 2) that choice relates to expected times and costs of the journey, for which measured data appears to be the best approximation of expected values.

B-45. Wheeler, J. O., "Transport Inputs and Residential Rent Theory: An Empirical Analysis, Geographical Analysis, Vol. 2, No. 1, pp. 43-54, January 1970.

An examination of the postulate that residence is selected to minimize work trip costs using Tulsa, Oklahoma as a case study. Work trips in Tulsa cannot be.explained by this postulate. The tendency to minimize work trips

B-45. (Continued)

by residential selection varies directly with socioeconomic status as suggested by residential rent theory.

B-46. Wildermuth, Bruno, *The Effect of Transportation on Residential Location*, Graduate Report, Institute of Transportation and Traffic Engineering, University of California, April 1964.

An examination of the relationships between transportation and decisions for residential locations. The author addresses residential transportation demands; cost measurement for various travel patterns; and the balance of time and money costs of person movements.

B-47. Wilson, A. G., "The Use of Entropy Maximizing Models in the Theory of Trip Distribution, Mode Split and Route Split," *Journal of Transport Economics and Policy*, Vol. 3, No. 1, pp. 108-126, January 1969.

A theoretical analysis and model of the relations of trip distribution to modal split, modal split to route split, and of directly observed to perceived costs. Empirical tests of the theory are suggested as a first step in developing a more accurate forecasting model.

B-48. Yapa, L., M. Polese and J. Wolpert, "Interdependencies of Commuting, Migration, and Job Site Relocation," *Economic Geography*, Vol. 47, No. 1, pp. 59-72, January 1971.

An examination of the relation between commuting and migration behavior and of the basis of this relation. A simple, four-region model is developed to specify expected relations.

B-49. Zupan, J. M., "Model Choice: Implications for Planning," *Highway Research Record*, Number 251, pp. 6-25, 1968.

A relation is developed between work trips and residential density (at both ends of trip), rail service availability, relative automobile and rail trip times, and toll and parking costs. The equation is a reasonable forecasting tool for each of three income groups in New York City.

B-50. Hill, Stuart L., and B. Frankland, "Mobility as a Measure of Neighborhood," *Highway Research Record*, Number 187, pp. 33-42, 1967.

An attempt to develop a quantitative measure of the impact of highways on community stability and cohesion. Neighborhood stability is assumed to be a function of population turnover, home ownership and single family residences. An index may be constructed from mobility characteristics (percent occupying same residence for five or more years and percent of older buildings occupied by same household throughout twenty years) and propensity to change (percent single family dwellings and percent owner-occupied units); a simplified index neglects occupancy characteristics of older buildings. The index presents some data problems since neighborhood boundaries may shift over time. The index is descriptive, not normative.

I. HIGHWAYS

C. Land Use and Land Value

C-01. Adkins, W. G., "Land Value Impacts of Expressways in Dallas, Houston, and San Antonio, Texas," Highway Research Board, Bulletin 227, pp. 50-65, 1959.

A review of the findings and methodologies of three economic impact studies dealing with land values as influenced by expressways from 1945 to 1957 in Houston (Gulf Freeway), Dallas (North Central Expressway), and San Antonio (Expressway). The analyses are based on real estate sales and utilize before/after and control area comparisons. Each case study is summarized and data requirements and measurement techniques are specified. It is suggested that land values are the best single indicator of economic impact since nearly all effects of highways are eventually reflected in land values.

C-02. Adkins, William G., J. E. Frierson, and R. H. Thompson, Farm Land Values and Rural Road Service in Ellis County, Texas 1955-58, Texas Transportation Institute, Texas A & M College, College Station, Texas, June 1960.

Relations between farm land values and quality of road service in Ellis County, Texas are analyzed from data on 214 farms sold during 1955-58. Analyses were conducted on land price, value of road type location. correlation of land use and road type, and buyer characteristics. It was found that land on paved roads was likely to be valued at a premium over land on gravel roads; locations on gravel roads were in turn more valuable than locations on dirt roads.

C-03. Ashley, R. H., and Berard, W. F., "Interchange Development Along 180 Miles of I-94," Highway Research Record, Number 96, pp. 46-58, 1965.

A description of land development and value increases at 66 interchanges along 180 miles of I-94 in Michigan. The study found that commercial uses, led by gas stations, predominated, with land values on the whole doubling, but for filling stations, rising five-fold. However, no control areas were used (except that gas stations further from interchanges were compared to those nearer for daily pumpage) and no causal mechanisms were advanced.

C-04. Bahl, R. W., Jr., A Bluegrass Leapfrog, Bureau of Business Research, College of Commerce, University of Kentucky, 1963.

A case study of "leapfrog" development in the suburbs of Lexington, Kentucky based on analysis of differential costs of development (travel, utilities, sewage, social services).

C-05. Barden, R., and J. H. Thompson, The Urban Frontier - Occasional Paper No. 4, Syracuse University, Urban Transportation Institute, 1971. NTIS (PB-204-056).

Residential real estate values are examined as they reflect urban sprawl, and reach a threshold at the "urban frontier." A model, applied to six

C-05. (Continued)

areas in New York (Syracuse, Utica-Rome, Albany-Schenectady-Troy, Rochester, Buffalo, and Binghampton) indicate three major factors in urban growth: (1) highway accessibility; (2) pregrowth population distribution; and (3) physical environmental characteristics.

C-06. Borchert, John R., *Beltline Commercial-Industrial Development - A Case Study in the Minneapolis-St. Paul Metropolitan Area*, University of Minnesota, Minneapolis, Minnesota, November 1960.

A comparative study of the physical development of land use with respect to the existing and proposed beltline routes around the Twin Cities to the west. The author analyzes the location of commercial and industrial land development along the west segment of the old route, evaluates the demand for similar land use along the new route, and discusses the study findings in terms of planning implications and highway land acquisition in urbanizing areas.

C-07. Brand, D., B. Barber, and M. Jacobs, "Technique for Relating Transportation Improvements and Urban Development Patterns," *Highway Research Record*, Number 207, pp. 53-67, 1967.

A description of the EMPIRIC land use forecasting model, with emphasis on: (1) information on the relative and absolute effect of transportation and community facility improvements on land use; and (2) results of EMPIRIC model use for two urban regions using three data sets. The model formulation, estimation of coefficients, and generalized equations reflecting urban development patterns are discussed.

C-08. Carroll, Donald D., J. R. Borchert, J. Schwinder, and P. M. Raup, *The Economic Impact of Highway Development Upon Land Use and Value: Development of Methodology and Analysis of Selected Highway Segments in Minnesota*, University of Minnesota, September 1958.

An examination of the process and causes of change in land use and value, and of methods for analyzing growth patterns spatially and over time. The study focuses on three highway segments in the Minneapolis area, including a bypass highway, a feeder into the city, and a limited access divided highway. Extensive use is made of aerial time series mapping. The study emphasis is on methodology, with implications for further use in impact analysis.

C-09. Cherner, M., "Property Values as Affected by Highway Landscape Developments," *Highway Research Record*, Number 53, pp. 4-7, 1964.

An examination of land values and community attitudes toward radial expressways, primarily in the suburban areas of Chicago. Selected areas were of mixed development densities, medium to high socio-economic levels, and were located near radial expressways. An attitude survey of residents showed a general willingness to purchase another home near an expressway (64%), and favorable views toward highway landscaping. These attitudes were correlated with increased land value (100-500%), and increased apartment rent levels.

C-10. Cockfield, R. W., "Proposed Logic Sequence for Designing Preliminary Urban Land Use Plans," Highway Research Record, Number 399, pp. 62-70, 1972.

Formulation of a design concept which aggregates a system of required land use activity into subsets subject to design restraints. Its potential role in the evaluation of alternative preliminary land use plans is described.

C-11. Cribbins, P. D., W. T. Hill, and H. O. Seagraves, "Economic Impact of Selected Sections of Interstate Routes on Land Value and Use," Highway Research Record, Number 75, pp. 1-31, 1965.

The economic effects of controlled-access facilities in North Carolina on surrounding property values and development are assessed using a before and after method and multiple regression analysis techniques for each study period. Three sections of Interstate Routes I-95, I-40, and I-85 in three counties are examined. These roads are radial-interurban highway segments in rural-urban fringe areas. Land values were examined as a function of: parcel size; year of sale; vacant/non-vacant land use; rural-urban land use; subdivision; roadside location (with respect to test facility); alternate roadway location (with respect to other major routes); and three location variables (straight-line distance to the central business district; to the right-of-way; and to the nearest interchange).

C-12. Davis, J. Tait, "Parkways, Values and Development in the Washington Metropolitan Region," Highway Research Record, Number 16, pp. 32-43, 1963.

Two parkways and one bypass highway in the Washington, D.C. metropolitan area are examined from 1950 to 1961. Because of their dual function as commuter and tourist roads, and because of extensive aesthetic emphasis in their design, land value and use patterns are probably unique. The parkways showed greater development and differing land uses than the highway. A factorial model was developed to analyze reasons for these variations, using measures of lot size, family income, size and condition of structure; results were largely inconclusive.

C-13. Eighmy, T. H., and J. J. Coyle, Toward a Simulation of Land Use for Highway Interchange Communities, Pennsylvania State University, 1965.

A proposed simulation model for predicting growth and development at interchanges. An assumption is that interchange development exhibits a pattern which is repetitive through time. Hypothetical examples of model use are presented.

C-14. Evans, E. E., Impact of Kokomo By-Pass, 1950 to 1964, Purdue University, August 1965.

An analysis of the long-range effects of an urban bypass, with specific reference to land use, land value, traffic volumes, travel times, and accidents.

C-15. Eyerly, R. W., Property Formation, Real Estate Value, and Land Use in Four York County Interchange Communities: An Interim Report, Pennsylvania State University, 1965.

An examination of land use and values within a two-mile radius of four interchanges near York, Pennsylvania. Using tax record data, analysis indicated that: (1) interchange area land values increased less than in surrounding areas; (2) interchanges nearest York showed the greatest land value increase; and (3) land use changes were slight.

C-16. Flaherty, M. C., "Commercial Highway Service Districts and the Interstate," Highway Research Record, Number 96, Washington, D. C., 1965.

A methodology for guiding land use development at highway interchanges by relating traffic volume, interchange design, and user costs. It attempts to specify how much land should be allocated for commercial use at interchanges.

C-17. Fleischman, E. R., The Impact After Seven Years of a Highway Improvement in a Small City, Purdue University, 1968.

Examination of changes in land use, land value, travel time, traffic volume, and accident rates after bridge construction. No control areas were used for comparison.

C-18. Garrison, William L., and M. E. Marts, Influence of Highway Improvements on Urban Land - A Graphic Summary, University of Washington, May 1958.

A survey of highway impact studies conducted before 1958, and a graphic overview of major findings. Twelve studies emphasizing changes in land values (New York, Texas, California, Illinois) and studies of bypass or relocated highway impacts on business activity in fourteen towns in California are summarized. Two analyses of traffic impact on land values and business are also presented.

C-19. Goldberg, M., "Transportation, Urban Land Values, and Rents: A Synthesis," Land Economics, Vol. 46, No. 2, pp. 153-162, May 1970.

An investigation of the relation between transportation values, rents and price elasticities of demand. It is suggested that a general improvement in transportation will result in a decline in economic rents in the aggregate, but not, necessarily, in real property and site rents.

C-20. Goldberg, M., "Economics of Transportation Corridors: Further Empirical Analysis," Highway Research Record, Number 410, pp. 37-51, 1972.

An examination of the economics of transportation corridors, particularly of early and substantial land acquisition for highway construction, with specific reference to the Vancouver, B. C. metropolitan area. A deflated price index for 325 randomly selected properties during a 19-year period showed that the rate of appreciation of property was less than the 8% opportunity cost of purchasing and holding. A rough estimate showed that

C-20. (Continued)

rental of acquired property is balanced by lost taxes and operating and maintenance expenses. However, a similar analysis for properties falling within 0.1 mile of an existing freeway (Trans-Canada Highway) showed an appreciation rate of 11% for land and 4% for land plus improvements.

C-21. Goldberg, M., "An Evaluation of the Interaction Between Urban Transport and Land Use Systems," Land Economics, Vol. 48, pp. 338-346, 1972.

A discussion of the indirect effects of urban transportation systems on land use and the spatial organization of the urban environment. A systems view of the urban region is presented based on the assumptions that (1) land values are determined by accessibility; (2) labor and capital are relatively constant in an urban area; (3) density is a determinant of regional attractiveness; and (4) impacts are exhibited through changes in site rents.

C-22. Golden, J. S., "Land Values in Chicago: Before and After Expressway Construction," Chicago Area Transportation Study, 65 pp., October 1968.

An empirical investigation of the secondary benefits of expressway construction in Chicago using statistical techniques. Land values were higher in test than in control areas with one exception. Land next to the expressways did not always appreciate most in value.

C-23. Hamburg, J. R., G. J. Brown, and M. Schneider, "Impact of Transportation Facilities on Land Development," Highway Research Record, Number 305, pp. 172-178, 1970.

A series of experiments with a model to explore the impact of centrality, magnitude of growth, network speed, network density, and network geometry on land development.

C-24. Hammel, L. V., K. C. Maffitt, and R. R. Roberts, "Transportation Considerations of Regional Shopping Centers," Traffic Engineering, Inst. Traffic Engineering, Vol. 42, No. 11, pp. 14-21, August 1972.

A study of the transportation considerations of regional shopping centers, with specific focus on land development and traffic operations.

C-25. Harvey, Robert O., and W. A. V. Clark, "The Nature and Economics of Urban Sprawl," Land Economics, Vol. 71, pp. 1-9, February 1965.

Urban sprawl is described as an economic phenomenon resulting from uncoordinated investment decisions of developers in the free market. Common land regulation practices, which leave outlying areas uncontrolled, and transportation improvements contribute to sprawl. The authors contend that sprawl is not necessarily an adverse phenomenon, that it is dynamic in character, and that it places an economic burden on the population only if accompanied by poor public planning.

C-26. Huhtanen, Robert J., et al., A Study of the Effects of Freeways on Central Business Districts, Clark University, Worcester, Massachusetts, February 1961.

An analysis of the effects of expressways on central business districts in terms of changes in land use, land value, access, and travel patterns. Three case study areas are examined (Richmond, Virginia, and Long Beach and Oakland, California), and the author uses land use mapping techniques for impact analysis.

C-27. Isard, W., and P. Liossatos, "On Location Analysis for Urban and Regional Growth Situations," Annals of Regional Science, Vol. 6, No. 1, pp. 1-27, June 1972.

A model addressing the dynamics of changing spatial patterns and processes over time. Analysis is based on the location of major facilities, new industrial districts, new shopping centers, new towns, new parks, and open spaces.

C-28. Isibor, E. I., Modeling the Impact of Highway Improvements on the Value of Adjacent Land Parcels, Purdue University, Indiana State Highway Commission, 1970.

A step wise, multiple linear regression procedure to account for land value increases following highway construction. Important variables are type of highway, type of land use, and location of parcel.

C-29. Kentucky, University of, The Effect of the Louisville Watterson Expressway on Land Use and Land Values, Lexington, Kentucky, 1960.

An analysis of the effects of the Louisville Watterson Expressway on land use and land value, using three time periods (pre-construction, during construction, and post-construction) and control area comparisons where possible. The expressway, a four-lane, limited access facility bordering Louisville on the south, was opened in 1956.

C-30. Kentucky, University of, Bureau of Business Research, College of Commerce, Certain Economic Effects of the Lexington Northern Beltline, Lexington, Kentucky, 1960.

An appraisal of the impact on land use and values of a 6-mile free-access bypass, built primarily for the relief of traffic congestion in downtown Lexington, Kentucky. The influence of the highway facility was derived by comparing the actual land use in the area presumably affected by the highway with the probable land use in the absence of the highway. Land value, land use, and case studies and surveys of commercial and industrial establishments on and off the beltline were studied. Changes in land use were considerable -- mainly changes to industrial and commercial use from other uses -- and were accompanied by significant changes in land values.

C-31. Lehr, R. L., Relationship of the Highway Interchange and the Use of Land in the State of Oklahoma, Oklahoma Center of Urban and Regional Studies, June 1965. NTIS (PB-172-988).

A two-part study including: a literature review on land use determinants, urban land use patterns, and industrial location theory; and case studies of

C-31. (Continued)

five intersections at grade, twenty-two interchanges, and four highway segments. Findings include: (1) interchanges attract multi-family housing, if the area is already suitable for residential construction; and (2) development of highway-oriented establishments is generally related to distance to the nearest urban area.

C-32. Lemly, J. H., "Changes in Land Values Along Atlanta's Expressway," Highway Research Board, Bulletin 227, pp. 1-20, 1959.

Examines changes in land use and values from 1941 to 1956 along a 7.5-mile segment of Atlanta's Northeast Expressway. Areas are characterized in terms of distance from the central business district; distance from the expressway; and accessibility to the expressway. Indicator variables are property sales and prices. Comparisons are made to control areas located in southern Atlanta.

C-33. Lemly, J. H., Expressway Influence on Land Use and Value, Atlanta 1941-1956, Georgia State College, School of Business Administration, Bureau of Business and Economic Research, 1958.

An evaluation of the impacts of Atlanta's Northeast Expressway (an infrequent access, radial highway) on land use and value. The affected area has a manufacturing-based economy and high density development. Comparisons are made between study areas (near the expressway) and control areas (equidistant from the central business district, but not near the expressway). Control areas remained largely residential, while study areas showed large increases in commercial and industrial land use, and land values. Streets in the study area, previously used for radial access, showed large decreases in overall traffic loads, but large increases in commercial traffic.

C-34. Lewis, J. E., "Transportation Theory of Urban Land Rent," Right of Way, Vol. 9, No. 2, pp. 23-28, April 1972.

A discussion of the hypothesis that site rents of urban land are composed of, and are equal to, the savings in transportation costs afforded by one location over another. Transportation improvements and population density changes are viewed as causes of rent level locational shifts. The author suggests additional empirical research.

C-35. Long, G. A., G. D. Long, and R. W. Hooker, A Corridor Land Use Study: The Impact of an Interstate Highway on Land Use Values, Private Investment and Land Use in Southwestern Wyoming, Wyoming University, FHWA, October 1972.

Land use surveys to assess economic impacts of an Interstate Highway (I-80) on a transportation corridor in southwestern Wyoming (including both cities and small towns). Redistribution of land values, land rents, and intensities of land use from the CBD's to the city peripheries was the most significant impact to date.

C-36. Massachusetts Department of Commerce and Development, *Future Development of Eastern Massachusetts Route 495 and Fringe Area, 1963 and 1975-1990*, Boston, Massachusetts, 1967.

An examination of the impact of highway development in Eastern Massachusetts, with specific reference to Route 495, a circumferential highway passing through urban and rural areas and connecting with several radial highways originating in Boston. The impact on 42 communities adjacent to Route 495 is examined using the EMPIRIC land use forecasting model. Impacts of two alternative highway plans are examined based on two growth patterns: a "composite" pattern which assumes that the City of Boston will remain dominant and that development will occur near three main radial sectors from the city; and a "controlled dispersal" pattern which assumes a more or less uniform, low-density population distribution throughout the region.

C-37. Milgram, Grace, *The City Expands: A Study of the Conversion of Land from Rural to Urban Use, Philadelphia 1945-1962*, University of Pennsylvania, Institute for Environmental Studies, March 1967.

An empirical study of the rise in price of vacant land and its relationship to time-distance to the central business district, proximity to public transportation, and availability of sewers over an 18-year period in a section of Philadelphia. Other factors, such as degree of development of vacant land, its potential uses, and the type of buyer and seller also influenced price.

C-38. Neuzil, D. R., *The Highway Interchange Problem: Land Use Development and Control*, University of California, Berkeley, Calif., 1963.

An analysis of problems created by land development in the vicinity of highway interchanges in suburban and semi-rural settings. Impact analysis includes land use, land values, types of development, traffic congestion, and hypothetical political/legal control mechanisms.

C-39. Northern Virginia Regional Planning and Economic Development Commission, *Highway Influence, Northern Virginia Region*, Arlington, Virginia, July 1962.

A study of areas in Loudoun, Fairfax, and Prince William Counties affected by planned Routes 66, 495, and 95 (all Interstate Highways) and by the new highway providing access to Dulles Airport. This is a "before" study which attempts to analyze current land use and estimate probable changes resulting from the new highways.

C-40. O'Flaherty, C. A., "People, Transport Systems, and the Urban Scene: An Overview - I," *Intl. J. Environmental Studies*, Vol. 3, No. 3, pp. 265-285, July 1972.

A discussion of the relationship between quality of life in urban areas, and long-term landuse and transport developments. Summaries of urban transport to date with specific emphasis on automobile use, and future transportation development in towns are presented.

C-41. Oklahoma, University of, Research Institute, The Relationship of the Highway Interchange and the Use of Land in the State of Oklahoma, Volumes I and II, Oklahoma Center of Urban and Regional Studies, 1965.

Volume I includes a discussion of land use determinants and decision making; the use of land and the urban pattern; and traffic generation and congestion. Volume II is an investigation of changes in land use at interchange locations on I-35 in the Oklahoma City metropolitan area, and on I-44 in the Tulsa Metropolitan Area.

C-42. Pendleton, W. C., "Relation of Highway Accessibility to Urban Real Estate Values," Highway Research Record, Number 16, pp. 14-23, 1963.

An examination of a radial, infrequent access highway in the Washington, D.C. area. A main hypothesis is that short-run route choices of drivers, long-run residential location decisions and highway building programs of public agencies operate together to equalize the accessibility structure of the city in terms of both direction and distance. Regression analysis is used to examine correlations between job accessibility and distance to CBD; driving time and distance to CBD; proportion of job trips and driving distance to CBD; and housing prices and job accessibility and driving time and distance to CBD. The analysis showed that sales prices set in the urban real estate market reflect accessibility differences and that sales data can be used to estimate accessibility values.

C-43. Philbrick, Allen, Analyses of the Geographical Patterns of Gross Land Uses and Changes in Numbers of Structures in Relation to Major Highways in the Lower Half of the Lower Peninsula of Michigan, Michigan State University, 1961.

The expansion of urban land uses and structures was related to the pattern of highway development in the Lower Peninsula area of Michigan by comparative mapping techniques. Gross land use changes over time were evaluated, and urban land uses correlated with distance from highways and distance from urban centers. Farm and non-farm dwelling units were also examined by mapping techniques. Ten dispersed city regions were identified and spatially related to a "web of highway impact" area.

C-44. Rockey, Melvin B., and J. C. Frey, Farms and New Highways: Problems and Adjustments, Pennsylvania State University, University Park, Pennsylvania, 1964.

Identification of impacts of a limited-access highway on farm operations, based primarily on interviews with sixty York County, Pa. farmers whose farms abutted a 38-mile segment of Interstate 83. Variables addressed included: land use changes; compensation mechanisms for land and buildings taken for the highway; adjustments by farmers after highway construction; and general attitudes of farmers toward compensation, highway location, and the negotiation process. Results showed that the most significant problem was physical separation of farms by the highway.

C-45. Rogers, Andrei, The Time Lag of Factors Influencing Land Development, (in collaboration with F. S. Chapin, Jr., T. G. Donnelly, and S. F. Weiss), Institute for Research in Social Science, University of North Carolina, Chapel Hill, N.C. October 1963.

Analysis of the time lag of primary factors as they act together to structure

C-45. (Continued)

spatial distribution of urban activities. The City of Greensboro, N.C. was the study area. Six key independent variables influencing land development are examined over a 12-year study period (1948-1960). The two most statistically significant independent variables ('accessibility to work areas' and 'distance to nearest elementary school') had lag times between 3 and 6 years.

C-46. Sauerlender, O. H., and R. B. Donaldson, Predicting Development at Non-Urban Interchange Sites on Pennsylvania Interstate Highways, Pennsylvania State University, 1965.

A model for predicting growth in interchange areas in Pennsylvania communities, based on thirteen selected variables (including average daily traffic, topography, distance to urban area, and percent county population change).

C-47. Schmidt, Blaine G., Delaware Highway Impact Study, Phase II Report (1959-1963), Bureau of Economic and Business Research, University of Delaware, 1967.

A study of the impact of Interstate Highways on New Castle County, Delaware. Land Use and land values are examined during pre-, in-, and post-construction using comparisons to control areas. Impacts during the construction period are initially negative; however, they are followed by upgrading of residences and location of new commercial establishments. The author concludes that the Interstate System will cause general economic activity enhancement within the state, an appreciation of land values, intensification of land use, and in the long run, an expanded tax base.

C-48. Schneider, M., "The Access and Development Prototype Project," Highway Research Record, Number 293, pp. 147-154, 1969.

A summary of an attempt to develop quantitative relations among travel, land development, and time and cost characteristics of transportation.

C-49. Spears, J. D., and C. G. Smith, A Study of the Land Development and Utilization in Interchange Areas Adjacent to Interstate 40 in Tennessee, Tennessee University, Tennessee Department of Highways, 1970.

An examination of land development (value and use) at 59 interchanges on I-40 between Memphis and Knoxville, Tennessee. Land development depended on local population density, demographic trends, land availability, secondary road characteristics, and suburbanization-industrialization patterns.

C-50. Stein, Martin, "Highway Interchange Area Development - Some Recent Findings," Public Roads, Vol. 35, No. 11, pp. 241-251, December 1969.

An evaluation of the development of areas surrounding highway interchanges and an attempt to relate types of land use to types of intersecting facilities. Using data on 316 interchanges in 16 states from 1960 to 1967, the study shows that development near interchanges depends on both the kind of intersecting highway and on the quadrant of the interchange. Further, rural interchanges

C-50. (Continued)

are developed almost exclusively by highway-oriented businesses (service stations, motels, and restaurants) while suburban interchanges show rapid growth of apartment buildings, churches, schools, shopping centers, and industrial parks. The report also reviews a number of efforts to develop models for predicting interchange development using several statistical approaches.

C-51. Stern, M. O., "A Planning Model for Transportation in Urban Activity Centers," *Highway Research Record*, Number 367, pp. 99-106, 1971.

A planning model for transportation in dense, specialized urban activity centers such as the central business district in central cities. The described model (a non-linear, statistical model) allows testing of new policies, land uses, and technological alternatives, and is used for predicting traffic patterns.

C-52. Swerdloff, C. N., and J. R. Stowers, "A Test of Some First Generation Residential Land Use Models," *Highway Research Record*, Number 126, pp. 38-59, 1966.

A comparative evaluation of five operational residential land use forecasting techniques. Included are: (1) the density-saturation gradient method; (2) accessibility model; (3) regression; (4) and (5) two intervening opportunity models. All conditions were held constant except the interrelationships between variables, and differences among results are discussed.

C-53. Thiel, Floyd I., "Highway Interchange Area Development," *Highway Research Record*, Number 96, pp. 24-45, 1965.

A discussion of congestion induced by intensive development at highway interchange locations. Possible land use controls to ameliorate this problem are suggested and local and state action to guide such development is supported. A summary of additional needed research on this subject is included.

C-54. Walsh, S. P., "Some Effects of Limited Access Highways on Adjacent Land Use," *Highway Research Record*, Number 229, 1968.

A proposal for various large scale residential, commercial, and public land uses near freeways based on quick access to urban areas, labor supply, larger market areas, central distribution of supplies, and advertising value.

C-55. Wootan, C. V., and C. R. Haning, *Changes in Land Value, Land Use, and Business Activity Along a Section of the Interstate Highway System in Austin, Texas*, Texas Transportation Institute, Texas A & M College, College Station, Texas, 1960.

Examination of land use, land value, and business activity along a 5-mile section of Interstate U.S.-81 (a four-lane, divided highway in Austin, Tx.) during 1941-1948 (preconstruction), 1949-1953 (land purchase and construction),

C-55. (Continued)

and 1954-1957 (post-construction). Substantially greater changes in land value were observed in the study area than in control areas. Land values in the study area were related to changes in land use and distance from downtown area. Overall business volumes were unchanged from 1953 to 1957, but individual businesses were affected to varying degrees by traffic flows.

C-56. Worral, R. D., "Census Data, Land Use, and Transportation Modeling," Highway Research Board Special Reports, No. 121, pp. 63-67, 1971.

Land use modeling, travel forecasting, impact analysis, and data maintenance and updating are discussed.

I. HIGHWAYS

D. Political-Legal

D-01. Bishop, A. Bruce, et al., Socio-Economic and Community Factors in Planning Urban Freeways, 1969. NTIS (PB-190-544).

An examination of urban freeways and of the planning process as it involves groups and individuals affected by freeways. Specific reference is made to the California freeways, but the conclusions are generally applicable. The report addresses four areas: 1) freeway planning as a process of social change; 2) attitudes and interactions of interest groups; 3) identification of social and economic factors in the planning process; and 4) definition of a method for comparing and evaluating user benefits and community impacts. A model for decision-making is also described.

D-02. Colcord, F. C., Urban Transportation Decision Making: Houston, A Case Study, 1970. NTIS (PB-206-224).

A case study of urban transportation decision-making in Houston, Texas. Major exogenous factors discussed include: absence of intergovernmental disputes; limited opposition to highway construction because of high degree of car ownership; good bus service; absence of downtown traffic congestion and adequate downtown parking. A large amount of highway construction during the 1960's channeled growth along the lines of transportation access and minimized neighborhood displacement in subsequent highway development.

D-03. Courtney, J. F., T. D. Klastorin, and T. W. Ruefli, "Goal Programming Approach to Urban-Suburban Location Preferences," Management Science, Vol. 18, No. 6, pp. B-258 - B-268, February 1972.

An analytic model to examine population location in a metropolitan area, designed for use in urban planning, real estate development, and transportation system design.

D-04. Coyle, J. J., et al., "Interchange Protection and Community Structures," Highway Research Record, Number 75, pp. 62-74, 1965.

A discussion of the relationship between community structure, land use policy, trip generation, highway congestion, and highway protection.

D-05. Fielding, Gordon J., "Structuring Citizen Involvement in Freeway Planning," Highway Research Record, Number 380, pp. 23-36, 1972.

A value analysis of social, aesthetic, economic, and design considerations in urban highway planning, as an aid for structuring community evaluation of alternative freeway corridors. A Los Angeles community case study is discussed, involving weighting of community goals (based on opinion surveys, discussions with elected officials, etc.), and a community-planners program of cooperation is described. Methods for evaluating and politically reconciling differences among impacted groups are described.

D-06. Hebert, R., Highways to Nowhere; The Politics of City Transportation, Bobbs-Merrill Company, Inc., New York, 1972.

An informal account of the effect of highways on urban centers, based on five "case studies" (Flint, Michigan; Dayton, Ohio; Indianapolis, Indiana; Atlanta, Georgia; and Washington, D. C.). It is suggested that while the automobile may not be destroying the urban cores singlehandedly, it is certainly dealing them a cruel blow.

D-07. Hill, Morris, "A Method for the Evaluation of Transportation Plans," Highway Research Record, Number 180, pp. 21-34, 1967.

A goals-achievement matrix for analyzing transportation objectives. Community goals and alternatives for achieving these goals are identified, based on: (1) goal statements in abstract terms (e.g., increased economic welfare); (2) stated objectives (e.g., increase resource utilization); (3) policies (e.g., highway design standards); and (4) constraints (e.g., time). These four categories form the dimensions of the proposed matrix. A set of indicator variables (demographic, business, and land use) is suggested and quantified where possible.

D-08. Hill, Stuart, "Watts-Century Freeway," Highway Research Board, Special Report, No. 105, pp. 117-122, 1969.

A description of the planning process used in Los Angeles for the Watts-Century Freeway. The relevant area is of high density and low socio-economic level, consists mainly of single-family dwellings, and has a predominantly black population. Emphasis is on the interaction of highway planners and the community; consideration of community values; and the potential of the Freeway to provide positive economic opportunities to the area.

D-09. Journal Urban Transportation Corporation, Urban Transportation Planning - Sources of Information on Urban Transportation, Report No. 4, June 1968. NTIS (PB-185-525).

A review of procedures followed in a comprehensive urban transportation planning process, including a history of its development, trip generation, trip distribution methods, traffic assignment techniques, modal split determination, economic forecasting, and plan implementation problems.

D-10. Lupo, Alan, et al., Rites of Way: The Politics of Transportation in Boston and the U.S. City, Little, Brown & Company, Boston, Massachusetts, 1971.

An account of expected social impacts and of public protest over planned Interstate construction in the Boston area, and a discussion of general trends in transportation planning and practices throughout the nation. The social effects addressed are land taking and aesthetics. One appendix contains a critique of the EMPIRIC land use forecasting model.

D-11. M.I.T. Urban Systems Laboratory, Community Values in Highway Location and Design, (Report No. 71-5), December 1971.

An approach to incorporating social and environmental factors into the highway planning process. Specific areas addressed include: the democratic basis for decision-making; highway planning and design as a socio-political process; the optimal process for choice when values are in conflict; and the role of the highway professionals in the planning process.

D-12. M.I.T. Urban Systems Laboratory, The Impact of Highways Upon Environmental Values, (Report No. USL-69-1), March 1969.

This Phase I report of a National Cooperative Highway Research Program describes an impact matrix for evaluating highway impacts on groups and individuals, and outlines a proposed program for further research.

D-13. Petersilia, Michael P., Community and Environmental Factors in Highway Location: A Case Study, M.S. Thesis (C.E.), 1972.

An assessment, based on the Urban Systems Laboratory (M.I.T.) approach, of Route 90, a 40-mile, 10-lane, radial highway in Los Angeles. The area has a low to medium socio-economic level with a manufacturing-commercial base. Impacts noted include: employment, induced infrastructure investment, racial distribution, land development, community cohesion, aesthetics, and taxes. A program for community/highway planner cooperation is presented.

D-14. Pikarsky, Milton, "Comprehensive Planning for the Chicago Crosstown Expressway," Highway Research Record, Number 180, pp. 35-51, 1967.

An examination of the planning process and of possible impacts for Chicago's Crosstown Expressway, a circumferential highway connecting the radial highway system. Impacts were addressed from three viewpoints: engineering, community, and land use changes. Seven alternative routes were considered on the basis of meeting criteria in each evaluation category. The eventual route location would not have been selected if the choice were based on engineering grounds alone.

D-15. Real Estate Research Corporation, A Study of the Impact of Major Highways on Local Tax Bases, prepared for the U.S. Department of Commerce, Bureau of Public Roads, 1960.

Examination of the effect of multi-lane, limited access highways on assessment, zoning, and taxing practices in Cook County, Ill. and Frederick County, Md. from approximately 1950 to 1960. These data, together with information provided from a questionnaire survey of assessing officials across the country, suggest that highways enlarge the tax base of larger metropolitan areas (provided undeveloped land is available) to a greater extent than for small cities; that taxing jurisdictions in the western and southern regions of the country benefit more by highways; and that special purpose highways have limited impact on the local tax base of jurisdictions they traverse.

D-16. Rogers, A. C., "The Urban Freeway: An Experiment in Team Design and Decision-Making," *Highway Research Record*, Number 220, pp. 20-28, 1968.

Highway planning problems in relation to a comprehensive urban transportation design policy. Cited deficiencies of highway planning include: highways are designed to serve users without considering communities and non-users affected by them; highways compete with, rather than complement, other transport modes. The renewal of downtown Cincinnati in 1963, and the Interstate Freeway System in Baltimore, Maryland, are cited as examples of comprehensive planning efforts. A team approach to design and decision-making and a national design policy are recommended.

D-17. Rothblatt, Donald H., *Regional Planning: The Appalachian Experience*, D. C. Heath and Company, Lexington, Massachusetts, 1971.

An historical review of the formation of the Appalachian Regional Commission, its program development and performance during its first three years (1965-1968), and of highway development as a major program focus in the region.

D-18. Scheiber, W. A., *The Metropolitan Washington Council of Governments*, National Academy of Engineering, October 1973.

A description of the national capital region, and characteristics of the Council of Governments. Unique problems in urban transportation are identified: (1) federal interest in decision-making; (2) conflict of local needs and federal dollars available; (3) conflict of city center and suburban goals; (4) diffusion of responsibility for transportation planning; and (5) the transportation impacts of land use decisions.

D-19. Tennessee State Planning Commission, *Highway Access Areas in Tennessee: A Study of Problems and a Suggested Program for Orderly Land Use Development*, Publication No. 321, Nashville, Tennessee, 1962.

Addresses different types of interchanges and common practices in land development around them with specific reference to the planned Tennessee Interstate System. Main concerns are planning alternatives and legal mechanisms.

D-20. Teska, R. B., "Social, Economic, and Environmental Impacts of a System of High-Accessibility Corridors," *Highway Research Record*, Number 356, pp. 119-129, 1971.

A definition of criteria to be met by transportation corridors in Chicago, with specific reference to the objectives outlined in the 1966 comprehensive city plan. Criteria include: incorporation of public and private transportation facilities; corridor land uses; functional and environmental relationships between transportation and land use; and integration of all high-accessibility corridors in a total system concept.

D-21. Tuzo, G. C., *The Evolution of the D. C. Highway System*, Consortium of University, Urban Transportation Center, June 1971. NTIS (PB-204-935).

An historical review of transportation artery development in the Washington, D. C. area and projected demands through the 1990's. Demands for streets

D-21. (Continued)

and highways generated by the introduction of the automobile and mass transit, and development growth patterns are traced. Four alternative plans for growth considered in the early 1900's are presented (planned sprawl, dispersed cities, peripheral communities, and radial corridor development). Rail rapid transit scheduled for completion before 1980 is discussed, and its role in radial growth is examined.

D-22. Wade, Philip E., *Highway Impact Analysis as a Basis for Project Implementation*, M.I.T., M.S. Thesis (C.E.), February 1971.

A framework for impact evaluation based on the M.I.T. (Urban Systems Laboratory) "interactive" planning approach. The author summarizes the evolution of highway planning since the 1950's, (highway needs approach; network analysis or community development; and interactive planning approach). Six categories of impacted community elements are defined: the public as highway user; the public as resident; the community at large; government agencies; business and industry; and rural interests.

D-23. Washington State University, Highway Research Section, *A Study of the Social, Economic and Environmental Impact of Highway Transportation Facilities on Urban Communities*, 1968. NTIS (PB-197-626).

Development of a set of procedures and a desirability rating system for use in the location and design of freeways in urban settings. Major areas of concern are design, sociological, and neighborhood economic considerations, and a "desirability rating scale" is developed based on these three factors. Impact areas addressed include: income, induced infrastructure investment, age structure, migration, racial distribution, land values, densities and distribution of land use, community cohesion, aesthetics, and recreation.

D-24. Wickstrom, G. V., "Integrated Measurement Framework for Transportation Planning," *Journal of Transportation Engineering*, American Society of Civil Engineers, Vol. 98, No. Te2, pp. 275-283, May 1972.

A measurement framework, expressed in terms of access to opportunities, for transportation planning. Emphasis is on integration of planning with social, economic, and physical considerations. The author suggests additional research to determine the access of the various user groups.

II. MASS TRANSIT

01. Allen, W. B., Developing and Testing of a Behavioral Modal Split Model, 1971. NTIS (PB-204-941).

An examination of mass transportation using a behavioral model to address: 1) the relationship between attractiveness of different transportation modes and their attributes; 2) principal determinants of modal choice (experience and habit); and 3) aspects of car ownership. A user profile includes income, age structure, racial distribution, and sex characteristics.

02. Ashford, N. and F. M. Halloway, The Effect of Age on Urban Travel Behavior (Report No. 1), Florida State University Transportation Center, June 1970. NTIS (PB-196-843).

A quantitative analysis of the effect of age on urban travel, using six cities of varying geographic location and population size for case study. Travel parameters (3 modes of transportation; 5 trip purposes) were correlated with socio-economic variables by regression models. Large variations in travel behavior and demand among age levels are indicated.

03. Bailey, R. F., The Travel Patterns of Persons Residing in High-Density Urban Areas, Polytechnic Institute Brooklyn, June 1972. NTIS (PB-207-179).

A model to project transportation requirements of high-density area residents. Results of a survey of the Coney Island section of Brooklyn, of regression analyses of the data, and of an expansion procedure for applying sample data to larger areas are given.

04. Barnes, C. W., Who Rides the Bus? Passenger Characteristics and Riding Patterns of the Sacramento Transit Authority, 1970. NTIS (PB-197-821).

A study to determine who rides Sacramento buses (6 to 9 A.M.) and why (on weekdays). Data examined includes: 1) sociological characteristics of passengers; 2) passenger origins and destinations; 3) riding patterns; 4) choice and capative riders; and 5) association of household income with passenger characteristics and riding patterns. A user profile is developed based on income, employment, age, racial distribution, and sex characteristics.

05. Boyce, D. E., "Notes on the Methodology of Urban Transportation Impact Analysis," Highway Research Board Special Reports, No. 111, pp. 41-44, 1970.

A critique of methodology used in urban transportation impact studies involving before-and-after measurements and control areas. Suggestions are made for an improved methodology. An example (Philadelphia-Lindenwold Rapid Transit Line) of application of the new technique illustrates the suggested use of control and replication concepts.

06. Boyce, D. E., B. Allen, R. R. Mudge, P. B. Slater, and A. M. Isserman, Impact of Rapid Transit on Suburban Residential Property Values and Land Development, Pennsylvania University, Regional Science Department, Wharton School, Nov. 1972.

A phase one summary report of impacts on residential property values caused by the Lindenwold transit line (operating since February 1969 between Philadelphia and New Jersey suburbs). Using real estate transaction and property characteristics data, case studies of land development policies and analysis of public finance, impact areas are identified. The authors' conclusions support the theory that travel cost time savings stemming from line use are reflected in the prices of residential housing.

07. California Business & Transportation Agency, Transportation-Employment Project, January 1970. NTIS (PB-208-119).

A test of the assumption that increased public transportation service can improve employment opportunities for residents of a disadvantaged area. Bus service was provided between south central Los Angeles and a major employment center outside that area. Findings showed that while improved transit increases the chances of obtaining work, in general it does not enable the poor to participate in the highly formalized and competitive job market; jobs made available to residents of the study area were generally low-paying and at great distance so that even bus transit costs were prohibitive.

08. Carlin, Alan and Wohl, Martin, An Economic Re-Evaluation of the Proposed Los Angeles Rapid Transit System, RAND Corporation, Santa Monica, California, (Paper P-3918), 1968.

Rebuttal of economic justification presented by Southern California Rapid Transit District for rail rapid transit system for Los Angeles.

09. Colcord, F. C., Urban Transportation Decision Making: Houston, A Case Study, 1970. NTIS (PB-206-224).

A case study of urban transportation decision-making in Houston, Texas. Major exogenous factors discussed include: absence of intergovernmental disputes; limited opposition to highway construction because of high degree of car ownership; good bus service; absence of downtown traffic congestion and adequate downtown parking. A large amount of highway construction during the 1960's channeled growth along the lines of transportation access and minimized neighborhood displacement in subsequent highway development.

10. Cooper, E., Methods of Improving Transportation Facilities for Inner-City Dwellers, Howard University, 1970. NTIS (PB-194-095).

An examination of methods for providing transportation services to inner-city residents and equality of access to employment, recreational, and other urban opportunities. Proposed case studies in Washington, Nashville, and New York will test the results of a previous study of New York City low-income residents on origin-destination; car ownership; and access to opportunities. The author contends that integrated planning of transportation and urban development is necessary; and that the government should assist inner-city dwellers in achieving mobility (e.g., subsidization of private personal vehicles).

11. Cort, C. J., "The Evaluation of Travelling Time," Journal of Transport Economics and Policy, Vol. 3, No. 3, pp. 279-286, September 1969.

A summary of theoretical problems and of data problems in treating reduction of travel times brought about by investment in transportation.

12. Davis, Frederick W., "Proximity to a Rapid Transit Station as a Factor in Residential Property Value," The Appraisal Journal, Vol. 38, pp. 554-572, October 1970.

A detailed study of a proposed Bay Area Rapid Transit (BART) station site in San Francisco to predict property value and land use changes. A comparative analysis of four areas situated at varying distances from the site indicated property values were greater nearer the subway site. Anticipated population growth, increasing residential property values, and increasing demand for commercial office space are discussed for the four areas.

13. Falcocchio, J., Modal Choices and Travel Attributes of the Inner-City Poor, Polytechnic Institute Brooklyn, September 1971. NTIS (PB-206-149).

A profile of inner city residents and their travel habits. Residents are disaggregated by race, age, household size, median income, occupation, automobile ownership, trips per household, trip purpose, and modal split. Data show that most inner city residents travel less, have less modal choice, less mobility and reduced opportunities for all trip purposes.

14. Gannon, Colin A., et al., The Impact of Rail Rapid Transit Systems on Commercial Office Development: The Case of the Philadelphia Lindenwold Speedline, University of Pennsylvania, June 1972.

A preliminary analysis of the impact of the Philadelphia-Lindenwold Speedline on commercial development and the real estate market for commercial office space. The economic spatial structure and growth of the Philadelphia metropolitan region, the nature of the commercial office real estate market, and local development trends are described.

15. Gilman, W. C. & Company, The Radial Express and Suburban Crosstown Bus Rider - Final Report, 1966. NTIS (PB-174-220).

Evaluation of a St. Louis bus demonstration project. Seven new radial express bus routes were established and operated for one year between residential suburban areas and the St. Louis central business district; and new, direct cross county bus service connections were provided between two rapidly developing commercial centers.

16. Greytak, D., Residential Segregation, Metropolitan Decentralization of the Journey to Work - Occasional Paper No. 3, Syracuse University, Urban Transportation Institute, July 1970. NTIS (PB-196-904).

An examination of the spatial redistribution of trade and manufacturing activities in urban areas. The concentration of professional jobs in the CBD and the migration of the skilled labor force to suburban residences; and the concentration of non-white residences in the central cities while

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unskilled manufacturing and trade job opportunities move away from the central city are discussed, and housing segregation is viewed as a significant factor in shaping these trends.

17. Gutowsky, A. R., A Model for Predicting Transit Ridership (Interim Report No. 7), April 1971. NTIS (PB-199-553).

A description of a model to predict ridership on an urban transit system. Independent variables used to generate transit demand are household characteristics and the characteristics of available transit modes (automobile and bus transit). Three factors were found to affect ridership levels -- household income, household size, and the travel time difference between auto and public transit.

18. Hamburg, J. R., G. J. Brown and M. Schneider, "Impact of Transportation Facilities on Land Development," Highway Research Record, Number 305, pp. 172-178, 1970.

A series of experiments with a model to explore the impact of centrality, magnitude of growth, network speed, network density, and network geometry on land development.

19. Heenan, G. Warren, "The Economic Effect of Rapid Transit on Real Estate Development," The Appraisal Journal, Vol. 36, pp. 213-224, April 1968.

Analyses the relationship between mass transportation and metropolitan growth, with specific reference to the Toronto area. Impacts discussed include: employment, per capita construction expenditures, transportation choice, use of public services, land use, aesthetics, and political/legal aspects. The primary focus is on real estate values and land use indices for describing impacts of the mass transit system.

20. Highway Research Board Special Reports, No. 111, pp. 50-53, 1970, "General Discussion of the Impact of the Bay Area Rapid Transit System on the San Francisco Metropolitan Region."

A discussion by a number of observers on measuring and forecasting relations between transportation, housing location decisions, and land value changes.

21. Journal Urban Transportation Corp., Urban Transportation Planning-Sources of Information on Urban Transportation, Report No. 4, June 1968. NTIS (PB-185-525).

A review of procedures followed in a comprehensive urban transportation planning process, including a history of its development, trip generation, trip distribution methods, traffic assignment techniques, modal split determination, economic forecasting, and plan implementation problems.

22. Kalachek, E. D. and M. M. Goering, Transportation and Central City Unemployment, Washington University, St. Louis, March 1970. NTIS (PB-192-493).

A refutation of the theory that lack of adequate transportation deprives inner city residents of the mobility required to obtain jobs. The study

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includes data for St. Louis on location of employment and residences in 1960; job hunting patterns; job tenure; and a survey of suburban manufacturing plants.

23. Kasoff, M. J., Socioeconomic Factors Underlying Public Transit Use in the Journey to Work - Occasional Paper No. 1, Syracuse University, June 1970. NTIS (PB-197-575).

An empirical model for evaluating socio-economic determinants of modal choice for work trips in medium-sized cities. Transit usage is determined by race; automobile ownership; marital status; family income; percentage of females in the labor force; family size; and population and employment density.

24. Koike, H., Planning Urban Transportation Systems: A Model for Generating Socially Desirable Transportation Network Configurations - Research Report No. 2, Washington University, Seattle Urban Planning and Civil Engr. Departments. NTIS (PB-199-290).

A model for designing transportation networks to increase the "satisfaction level" - an index depending on transportation accessibility, employment accessibility and socio-economic status. A weighing function favors least satisfied residents in an urban area.

25. Kurkhardt, J. E. and M. T. Shaffer, "Social and Psychological Impacts of Transportation Improvements," Transportation (NETH), Vol. 1, No. 2, pp. 207-26, August 1972.

A discussion of the social impacts of transportation improvements in urban neighborhoods. The identification of social impacts, suggested measurement techniques, and the need for transportation planners to consider these impacts in the planning process are presented.

26. Langfield, S. C., The Balanced and Orderly Development of the Site in Close Proximity to a Metro Station as a Contributor to a More Healthy and Economically Viable Urban Environment in the Washington Metropolitan Area, Consortium of University, Urban Transportation Center, June 1971. NTIS (PB-203-783).

The relationship between rapid mass transportation construction and surrounding land use and value. Zoning policies in San Francisco and Toronto are examined to illustrate the author's contention that increased accessibility (provided by transit) causes activities to shift to the most accessible locations, promoting intensive land use and greater land value. Potential growth and development of a North Bethesda, Maryland transit site is examined in view of existing land use, assessed valuation, and zoning.

27. Lee, J. W., "Framework for Using Social Indicators to Monitor, Evaluate and Improve a Public Transportation System," Highway Research Record, Number 410, pp. 24-36, 1972.

An examination of social indicators (variables to measure social performance) for public transportation systems. After a discussion of an overall framework four indicators are selected: origins, destinations and number of female

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adult users (a large and particularly dependent group of users); ability to pay (weekly transportation cost divided by weekly income); number and time of daily work trips; and monthly vandalism cost. Measurement and collection techniques are discussed and the use of vandalism indicators in Atlanta, Georgia is illustrated.

28. Lewis, J. E., "Transportation Theory of Urban Land Rent," Right of Way, Vol. 9, No. 2, pp. 23-28, April 1972.

A discussion of the hypothesis that site rents of urban land are composed of, and are equal to, the savings in transportation costs afforded by one location over another. Transportation improvements and population density changes are viewed as causes of rent level locational shifts. The author suggests additional empirical research.

29. Lisco, T. E., "Value of Commuters Travel Time - A Study in Urban Transportation," Highway Research Record, Number 245, p. 36, 1968.

A modal choice study based on household interview data collected as part of the Chicago Skokie Swift Mass Transportation Demonstration Project. Analysis of times and costs for alternative trip modes inferred by choices of commuters, and the effects of commuter characteristics (e.g., income) on modal choice was conducted. Results showed that: (1) typical commuters value time at 4 or 5 cents per minute, and value comfort at $2.00 per day; (2) that commuters will choose between transit and automobile travel based on time and cost benefits; and (3) the discomfort of walking time is significant (an indication that placement of transit stations may be important in determining use).

30. Arthur D. Little, Inc., Center City Transportation Project - Descriptive Summary, September 1970. NTIS (PB-198-610).

A multidisciplinary approach to generate information about transportation requirements in the core cities of Atlanta, Dallas, Denver, Pittsburgh, and Seattle. Project objective was to establish priorities for near-term transportation improvements, and eventual accommodation of new technologies. Institutional barriers to improvements in center city mobility (e.g., lack of planning coordination, local financing of public transit) are discussed. Disparities among studied cities are noted, and demonstration projects for each area are proposed. (Note: separate reports are published for each city.)

31. Manarolla, J. A., The Trip to Work - A Submodule of a General Metropolitan-Regional Area Man-Machine Simulation, Consortium of University, Urban Transportation Center, 1970. NTIS (PB-194-099).

A general operational simulation of a metropolitan or regional area. Variables include spatial relations, private economic activities, local government functions, and federal/state aid, and personal functions (job seeking, demand for public facilities, leisure time activities, voting behavior). A gaming situation is used to assess travel time, convenience, and costs in determining modal choice for journeys to work.

32. Meyburg, A. H., "Analysis of Relationships Between Intercity Passenger Transportation and the Socio-economic Characteristics of Metropolitan Areas," *Transportation Research Forum*, Vol. 13, No. 1, pp. 271-84, 1972.

Development of measures of socio-economic characteristics of metropolitan areas, with specific reference to intercity transportation system characteristics. Forty metropolitan areas in the Northeast Corridor are analyzed over a 30-year period, and the significance and stability of statistical relationships are examined.

33. Meyer, J. R., J. F. Kain and M. Wohl, *The Urban Transportation Problem*, Harvard University Press, Cambridge, Mass., 1965.

An examination of urban transportation systems including highways and mass transit. The focus is on the effect of transportation on the overall metropolitan environment.

34. Murin, W. J., *The Evolution of Metro*, Consortium of University, Urban Transportation Center, 1970. NTIS (PB-194-100).

A summary of the evolution of the Washington, D.C. area subway system from early legislation (1950's) through adoption (1969), with emphasis on the decision-making process. This is part of a larger effort which will address these issues more broadly, and analyze the needs and access opportunities of the inner-city residents.

35. Notess, C. B., "Access to Jobs and Willingness to Travel," *Highway Research Record*, Number 392, pp. 143-146, 1972.

Development of a model-based, aggregate measure of willingness to travel to work. The author contends that data on the spatial distribution of jobs . for the occupational groups considered is necessary for an effective measure. A summary of previous studies on bus transit experiments to improve access to suburban jobs is also presented.

36. O'Flaherty, C. A., "People, Transport Systems, and the Urban Scene: An Overview - I," *Intl. J. Environmental Studies*, Vol. 3, No. 3, pp. 265-85, July 1972.

A discussion of the relationship between quality of life in urban areas, and long-term land use and transport developments. Summaries of urban transport to date with specific emphasis on automobile use, and future transportation development in towns are presented.

37. *Official Proceedings*, Fourth International Conference on Urban Transportation, Pittsburgh, March 10-12, 1969.

Papers presented in this publication examine: transit progress in Europe, legislation and federal highway policy, city transportation and growth, urban transport and inter-governmental relations. Various economic, social, and land use impacts are discussed.

38. Reinsburg, Mark, Growth and Change in Metropolitan Areas and Their Relation to Metropolitan Transportation, Northwestern University, Transportation Center, Evanston, Illinois, 1961.

A discussion of the roles of mass transit and automobile transportation in the decline of the central business district (CBD). Congestion of the inner city because of increased automobile use, migration of higher income families to the suburbs, migration of industry from the CBD, and a reduced tax base in the inner city are noted. The declining use of mass transit, the possibility of subsidy for mass transit, and the role of the CBD as a "seed bed" for new small firms are discussed. It is suggested that survival of urban mass transit in its present form is unlikely.

39. Romanoh, Eliahu, Impact of Mass Transit Construction on the Massachusetts Economy, Regional Science Research Center, Cambridge, Massachusetts (Paper No. 72-2), 1972.

A preliminary investigation of the effect of mass transit construction on the economy of Massachusetts in terms of employment generated in the heavy construction industry (SIC 1621), and estimates of resulting employment in other industries. An input-output model of the Massachusetts economy is used in deriving these preliminary figures.

40. Roszner, E. S., The Impact of Rapid Transit: An Evaluation of the Proposed Allegheny County Transit Expressway Revenue Line, Carnegie Mellon Univ., Transportation Research Institute, July 1971.

A benefit-cost analysis of the proposed 11-mile transit expressway revenue line to be located in the south hills area of Pittsburgh. Measurable economic benefits were projected for 1975-2010; non-measurable benefits for the community included improved local bus services, diverted long-haul traffic, reduced automobile congestion, promotion of orderly land use development, mobility for low-income persons, improved access to civic activities and facilities, and employment in construction and operation of the line.

41. Sheldon, Nancy W. and R. Brandwein, The Economic and Social Impact of Investments in Public Transit, Harbridge House, Inc., Published by Lexington Books, Lexington, Massachusetts, 1973.

An overview of user, operator, and community benefits derived from improvements or extensions of public transportation, and summaries and analyses of case studies on rapid rail transit, bus transit, and commuter rail systems in U.S. metropolitan areas. The authors suggest that frequently, though not always, public transit is a good alternative to highways in urban areas, providing broad social benefits; that for defined transportation objectives, rail rapid transit, as an alternative to auto and bus transportation, ranks first in terms of total benefits; and that use of Highway Trust Fund revenues to support public transit would be an equitable, socially responsible, and efficient policy decision.

42. Simpson and Curtin, The Traffic Rider, 1968; Interim Report No. 1, 1969. NTIS (PB-195-838).

A survey conducted in the Minneapolis-St. Paul area to develop a profile of bus riders. Riders are classified according to age, sex, annual family

42. (Continued)

income, automobile ownership and captive vs. choice riders. A profile of trip patterns is also developed according to route patronage, travel to the central business district, trip purpose, and travel means to and from buses.

43. Skidmore, Owings & Merrill, Center City Transportation Project: Urban Design Guideline, September 1970. NTIS (PB-198-600).

Case studies of five cities (Denver, Dallas, Atlanta, Pittsburgh, Seattle) including evaluation of urban design work programs, and a field survey of communities in each area. Three levels of urban design are addressed: (1) city form; (2) transportation architecture; and (3) human factors.

44. Stanford Research Institute, Future Urban Transportation Systems: Impacts on Urban Life and Form-Final Report II, Menlo Park, California, March 1968. NTIS (PB-178-266).

Formation of a hypothetical future urban area (4 million inhabitants; largely free from present tax and government constraints; and consisting of multiple centers within a central urban concentration) to test public transportation flows and evaluate potential physical, economic, and social impacts of transportation concepts. Analysis of the relationships between demography, transit network characteristics, and design solutions was conducted.

45. Studholme, E. D., Metro Impact in Arlington County: A Case Study and Evaluation of a Transit Growth Model, Consortium of University, Urban Transportation Center, June 1971. NTIS (PB-204-934).

A critical evaluation of two proposed models of growth in proximity to rapid transit stations in Arlington County, Virginia. Four variables are addressed: population size; population and building density; land use zoning; and circulation and mobility. The author criticizes several planning assumptions (e.g., transportation accessibility and water and sewer capacities are not good predictors of population growth); and contends that the models do not address increased growth opportunities in all sectors of the surrounding community.

46. Sweek, J. E., Evaluating the Central City Access Opportunity Provided by a Public Transportation System - Research Report No. 1, Washington University, Seattle, 1970. NTIS (PB-198-140).

A methodology to measure access opportunities provided to urban residents by a public transportation system. Access opportunity is measured by travel time and costs, and a "query-type" system is developed for assessing an individual's transit convenience. An alternative bus system and proposed rail rapid transit route in the Seattle, Washington CBD were tested, and the author concludes that the rail transit would offer only a marginal increase in access opportunities because of high relative transfer time costs.

47. Teska, R. B., "Social, Economic, and Environmental Impacts of A System of High-Accessibility Corridors," Highway Research Record, Number 356, pp. 119-129, 1971.

A definition of criteria to be met by transportation corridors in Chicago, with specific reference to the objectives outlined in the 1966 comprehensive

47. (Continued)

city plan. Criteria include: incorporation of public and private transportation facilities; corridor land uses; functional and environmental relationships between transportation and land use; and integration of all high-accessibility corridors in a total system concept.

48. Tuzo, G. C., The Evolution of the D.C. Highway System, Consortium of University, Urban Transportation Center, June 1971. NTIS (PB-204-935).

An historical review of transportation artery development in the Washington, D.C. area and projected demands through the 1990's. Demands for streets and highways generated by the introduction of the automobile and mass transit, and development growth patterns are traced. Four alternative plans for growth considered in the early 1900's are presented (planned sprawl, dispersed cities, peripheral communities, and radial corridor development). Rail rapid transit scheduled for completion before 1980 is discussed, and its role in radial growth is examined.

49. Voorhees, Alan M. & Associates, Inc., A Systems Analysis of Transit Routes and Schedules, November 1969. NTIS (PB-189-269).

A series of computer programs to assist in formulating long-range plans for public transit systems, and utilizing the Washington, D.C. transit system for case study. Alternative systems were developed, analyzed, and compared based on: (1) results of a passenger origin-destination survey in 1966; and (2) operating characteristics of the current D.C. transit system (route location, bus headways, bus speeds, operating costs, field-counted passenger volumes).

50. Wachs, M., "Employment, Mobility, and Public Transportation in Chicago: A Survey of Attitudes and Behavior," Highway Research Record, Number 148, pp. 142-151, 1971.

An interview survey in Chicago to examine relationships between employment status (employed vs. unemployed) and mobility. Differences in accessibility, dependence on public transit, and quality of service are evaluated with the objective of determining how to provide better linkages between the unemployed and available jobs.

51. Wickstrom, G. V., "Integrated Measurement Framework for Transportation Planning," Journal of Transportation Eng., American Society of Civil Engineers, Vol. 98, No. Te2, pp. 275-283, May 1972.

A measurement framework, expressed in terms of access to opportunities, for transportation planning. Emphasis is on integration of planning with social, economic, and physical considerations. The author suggests additional research to determine the access of the various user groups.

52. Zwick, Charles J., "The Demand for Transportation Services in a Growing Economy," Highway Research Record, Number 2, pp. 3-5, 1965.

Causal relations between transportation and economic growth and how they have changed over time. It is suggested that transportation shaped economic growth

52. (Continued)

in the past, but that today forces exogenous to the transportation system determine economic development. Mobility of labor and capital and increasing dominance of these two factors over raw material inputs in industry allow industry to locate near its markets rather than near raw materials. Rising personal income has led to willingness to pay for quality in transportation service. Future transportation systems will be determined by economic forces and demands for quality service.

III. WASTEWATER FACILITIES

01. Grava, Sigurd, *Urban Planning Aspects of Water Pollution Control*, Columbia University Press, New York, 1969.

Examination of the implications of sewerage collection and treatment systems for urban planning. The focus is on interactions of wastewater systems with the general administrative and financial aspects of city management. The assumption is made that sewer lines tend to attract development but no empirical evidence is presented in support of such a relationship.

02. Greenberg, Michael R., "Issues in Waste Water Treatment Facility Location," *Growth and Change: A Journal of Regional Development*, Vol. 3, pp. 38-43, January 1972.

An analysis of potential disadvantages of regional sewerage systems and of the possible relative benefits of localized facilities. Secondary impacts cited include employment, land development, and land values.

03. Li, C. Y., "Sewerage Plan Involves Open Space Preservation," *Civil Engineering*, Vol. 43, pp. 85-86, January 1973.

Description of a regional sewerage plan for York, Pennsylvania, and discussion of possible design alternatives to control sprawl and minimize undesirable development. Alternatives include the use of force mains to discourage unwanted hook-ups and minimize traversal of open spaces by interceptor sewers.

04. Metropolitan Council of Governments (Washington Metropolitan Area), Department of Health and Environmental Protection, *Analysis of the Joint Interactions of Water Supply, Public Policy, and Land Development Patterns in an Expanding Metropolitan Area*, Final Report to the Office of Water Resources Research, U.S. Department of the Interior, September 1973.

Possible relations between sewer extensions and population growth in the Washington Metropolitan Area are statistically examined in the period 1960 to 1968. Simple statistical analysis by watershed suggests a relation between population growth and sewer capacity. A relation with higher statistical significance was obtained when the amount of vacant land divided by its average straight line distance to trunk sewer service was also included. Analysis of the same data by EMPIRIC model districts does not yield results consistent with those found for watersheds.

05. Metropolitan Council of Governments (Washington Metropolitan Area), *Water and Sewerage Plan and Program 1971-1972*, 1971.

Progress report on a project to identify the effects of water and sewerage service on population growth and employment in the Washington, D. C. Metro-

05. (Continued)

politan Area. Data are being collected to derive mathematical relations to predict impacts of sewer and water service extensions on developmental patterns.

06. Milgram, Grace, The City Expands, Institute for Environmental Studies, University of Pennsylvania, Philadelphia, Pennsylvania, prepared for the U.S. Department of Housing and Urban Development, March 1967.

An empirical study of the rise in price of vacant land and its relationship to time-distance to the central business district, proximity to public transportation, and availability of sewers over an 18-year period in a section of Philadelphia. Other factors, such as degree of development of vacant land, its potential uses, and the type of buyer and seller also influenced price.

07. Ohio-Kentucky-Indiana Regional Planning Authority, Regional Sewerage Plan, November 1971.

A description of the sewerage plan for the Ohio-Kentucky-Indiana planning region. The proposed wastewater system was designed so that new interceptor sewers serve a minimum of land set aside for conservation in the area's comprehensive land use plan.

08. Rivkin/Carson, Inc., Population Growth in Relation to Water Resources Policy, Washington, D. C., October 1971.

An examination at a high level of aggregation of trends in urban growth in relation to water resource investments. Statistical analysis suggested that water resources development by itself has no impact on regional growth rates.

09. San Diego Comprehensive Planning Organization, Water Distribution and Sanitary Sewerage Systems: Background and Policy Study, 1972. NTIS (PB-214-261).

An outline of goals and policies for sewerage planning in San Diego County, California, including a brief discussion of developmental effects of sewerage works. Sewer extensions must be timed and located to support rather than conflict with land use plans. A policy of locating and sizing sewers to control the rate, density, and sites of new development in the county is suggested.

10. Stansbury, Jeffrey, "Suburban Growth: A Case Study," Population Bulletin, Vol. 28, April 1972.

A largely qualitative description of the influence of interceptor sewers on development in Fairfax County, Virginia. Major extensions of the sewer system into undeveloped portions of the study area were rapidly followed by sprawl type residential development. It is suggested that the particular complex set of local conditions (growth pressure, soil characteristics, zoning

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practices, wastewater investment policies) combined to make interceptor sewers the primary determinant of location and intensity of new development. New development created intense pressure on public services and caused increased tax burdens. The study attributes these effects to poor land use planning and control, the "subsidy" that public sewers provided to developers and the desire for increased hook-up revenues on the part of the local sewer authorities.

11. U.S. Environmental Protection Agency, Region II, Wastewater Treatment Facilities Grants for Nassau and Suffolk Counties, New York, July 1972.

Twelve wastewater treatment projects in Nassau and Suffolk Counties, New York are described. The projects include improvement of existing plants, construction of new plants, sewers, and outfalls. Concern is expressed on the effect of development on groundwater supplies.

12. U.S. Environmental Protection Agency, Region III, Bethany Beach (Delaware) Regional Wastewater Treatment Plant, Environmental Impact Statement, December 1972.

A proposed regional system including treatment plants and sewer lines to serve Bethany Beach, Sussex County, Delaware. Potential impacts on land use, density, and property values are discussed.

13. U.S. Environmental Protection Agency, Region IV, Cobb County (Georgia) Sewerage Improvement Project, Environmental Impact Statement, July 1971

A description of proposed construction of a centralized waste treatment facility and interceptor sewer lines to serve Cobb County, Georgia. Small public and private package plants now in operation will be phased out. Potential impacts on recreational land use and development are discussed.

14. U.S. Environmental Protection Agency, Region VI, Wastewater Facilities, Hot Springs, Arkansas, Environmental Impact Statement, October 1972.

A proposed central treatment plant and interceptor sewer lines for the area in and around Hot Springs, Arkansas. Population and land use trends and projections are given and possible impacts of the proposed facilities are discussed briefly.

15. Updegraff, Gail E., "The Economics of Sewage Disposal in a Coastal Urban Area: A Case Study of the Monterey Peninsula, California," Natural Resources Journal, Vol. 11, pp. 373-389, April 1971.

A description of the planning process in the Monterey, California region, where new sewerage plans were necessitated by legal action to stop pollution of coastal waters. The focus is on analysis of decision processes, possible alternative plans, and of political controversies.

IV. MODELS

01. Alonso, William, *Location and Land Use: Toward a General Theory of Land Rent*, Harvard University Press, Cambridge, Massachusetts, 1965.

Agricultural rent theory is extended to urban land values. A mathematical analysis of the locational equilibrium of households and firms is generated through bid price curves, and the effects of economic development on urban land use and land values are evaluated.

02. Birch, David, R. Atkinson, S. Sandstrom, and L. Stack, "The New Haven Laboratory: An Overview," *Proceedings of the 1973 Summer Computer Simulation Conference*, Montreal, Canada, July 1973.

An effort to develop a highly flexible model of metropolitan area growth. Regional totals and census tract locations of population, employment, and land use are generated. Implicit feedback loops govern migration, job growth, and housing construction.

03. Blackburn, James, *RIVERZ - A River Basin Planning Model*, Preliminary Report for the National Sanitation Foundation and Center for Environmental Study, December 1972.

The water sector of the Susquehanna River Basin Model is reformulated in an application to the Grand River Basin.

04. Brigham, E. F., *A Model of Residential Land Values*, RAND Corporation, Santa Monica, California, 1964.

An attempt to correlate a number of factors with land values in radial segments of Los Angeles. The poor results obtained are partially attributed to improper selection of independent factors used in the analysis. Selected factors were: distance to the central business district; average family income in the census tract; percentage of nonwhite families in the tract; a measure of crowding; building values; and topography.

05. Catanese, Anthony J., *New Perspectives in Urban Transportation Research*, Lexington Books, Lexington, Massachusetts, 1972.

A compendium of transportation oriented models representing a range of purposes and techniques. Included are theory, structure, and application of formulations treating: land use; trip distribution; commuting; and gravity model techniques.

06. Center for Real Estate and Urban Economics, *Jobs, People and Land: Bay Area Simulation Study (BASS)*, Institute of Urban and Regional Development, University of California, Berkeley, California, Special Report No. 6, 1968.

BASS is designed to test the impact of a range of assumptions on land utilization in the multi-county San Francisco Bay Area. Residential and industrial submodels allocate to regional subdivisions population and employment totals generated by regional growth submodels. Residential location is assumed to be entirely dependent upon accessibility to employment. Allocations of industrial changes, however, employ a wide range of location criteria. Notable among these is the allocation of discrete manufacturing facilities to geographic subareas according to "essential" conditions for a given industry and to relative advantages over other candidate subareas.

07. Chapin, F., Jr., "A Model for Simulating Residential Development," *Journal of the American Institute of Planners*, Vol. XXXI, No. 2, pp. 120-125, May 1965.

Commonly known as the University of North Carolina (UNC) model, this formulation addresses the conversion of land from open space to residential use. The model operates recursively over time, probabilistically allocating households to sub-areas according to measures of relative attractiveness (e.g., accessibility to work, schools, and major streets, and availability of public sewers).

08. CONSAD Research Corporation, *Impact Studies: Northeast Corridor Transportation Project, Volumes I, II, III, IV*, prepared for the Northeast Corridor Transportation Project, Office of High-Speed Ground Transportation, U.S. Department of Transportation, 1967, 1968, 1969, 1970.

A model for forecasting the impact of various transportation systems in the Northeast Corridor of the United States on population, economic activity, income, and land use. The model emphasizes the concept of "comparative advantage" of alternative locations in determining geographic distribution of activities. A non-spatial model (ECON) of economic activity in the Corridor provides inputs to a dynamic intraregional location model (INTRA). Regression analysis is used to calibrate the econometric equations in both models.

09. Crecine, John P., "TOMM (Time Oriented Metropolitan Model)," *Community Renewal Program Technical Bulletin*, No. 6, Pittsburgh, Pennsylvania, January 1964.

An adaptation of Lowry's "Model of Metropolis" for modeling household and retail location of the city of Pittsburgh. Revisions are disaggregation of population by income and a time-stepping simulation format. TOMM is one of three models constituting the Pittsburgh Urban Renewal Simulation Model.

10. De Leeuw, Frank, *The Distribution of Housing Services: A Mathematical Model*, Working Paper 208-1, The Urban Institute, Washington, D. C., 1971.

An equilibrium, one-step projection of the distribution of families and single persons among concentric zones of a hypothetical metropolitan area.

10. (Continued)

A utility function for households is based upon housing costs and quality, travel times, and average zonal income. A linear program maximizes household utility and the profit of landlords (who adjust housing prices and maintenance levels in response to demand).

11. Ellickson, Bryan, "Jurisdictional Fragmentation and Residential Choice," *American Economic Review*, Vol. 61, pp. 334-339, May 1971.

A theoretical exposition of household location based on the postulate that an equilibrium solution exists only when households locate in a pattern that stratifies population by wealth. Housing prices, tax rates, and the quality of public services are assumed to be the only determinants of household location.

12. Engle, Robert F., III, F. M. Fisher, J. R. Harris, and J. Rothenberg, "An Econometric Simulation Model of Intra-Metropolitan Housing Location: Housing, Business, Transportation, and Local Government," *American Economic Review*, Vol. LXII, No. 2, pp. 87-97, May 1972.

A series of models intended to evaluate policy alternatives at different governmental levels with respect to the development of Boston. A set of models is proposed to provide regional forecasts of industry and population and their distribution within the region. Two models -- the macroeconomic and long-term adjustment models -- provide population, employment, and income as inputs to the location model. The intraregional location model addresses dynamic market processes involving durable housing structures. The colocation of housing with other zonal attributes (e.g., accessibility, tax rates) determines location decisions.

13. Environmental Impact Center, Inc., *A Methodology for Assessing Environmental Impact of Water Resources Development*, First and Second Quarterly Reports to the Office of Water Resources Research, Department of the Interior, 1972, 1973.

This work expands the dynamic regional simulation formulation of the Susquehanna River Basin Model. Employment and household location decisions are simulated at a finer level of geographic detail by examining the interactions of supply and demand in the land market.

14. Forrester, Jay W., *Urban Dynamics*, M.I.T. Press, Cambridge, Massachusetts, 1969.

A dynamic simulation model is presented for potential application to the analysis of the effects of public policies on the development of a city. The formulation emphasizes (1) the interdependence of the components of the system; and (2) the manner in which the relative "attractiveness" of an area is subject to change as a result of decisions, based upon past attractiveness, by population and industry.

The model simulates the interrelated behavior of taxes, land availability, industries, population, and housing. The overall behavior generated is

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characterized by stages of growth, stagnation, and eventual decay of a hypothetical city. A range of governmental policies including job training and slum demolition programs are tested with the model.

15. Garn, Harvey A., and R. H. Wilson, A Critical Look at Urban Dynamics: The Forrester Model and Public Policy, The Urban Institute, Washington, D. C., 1970.

Forrester's Urban Dynamics model is reviewed and shortcomings of the formulation are discussed. The selection of boundaries and major sectors and the use of multiplicative relationships are examined. The authors provide alternative formulations and compare the results of simulated policies with those generated by Forrester.

16. Ginn, J. Royce, The NBER Prototype Urban Simulation Model, Preliminary Draft, National Bureau of Economic Research, Inc., March 1973.

A model of the Pittsburgh area housing markets simulating the interaction of housing supply and demand and the effects of policies andprograms. Household location criteria are accessibility to work, and housing and neighborhood characteristics. A linear program generates distribution of residential demand by minimizing total travel costs. Supplies of housing are governed by the profitability (to landowners and developers) of construction, filtering, and transformation.

17. Goldberg, Michael A., "An Industrial Location Model for the San Francisco Bay Area," Annals of Regional Science, Vol. 1, pp. 60-73, December 1967.

A component model treating location of industries for the Bay Area Simulation Study (BASS). Its most notable feature is the assignment of discrete manufacturing facilities to specific locations, as opposed to a continuous allocation function. Further technical details are available in the precis of Jobs, People, and Land.

18. Goldner, William, "The Lowry Model Heritage," Journal of the American Institute of Planners, Vol. XXXVII, Number 2, pp. 100-110, March 1971.

A discussion of the adaptations, conceptual revisions, and applications of Lowry's Model of Metropolis. Changes examined relate to the use of dynamic formulations, the degree of disaggregation, developmental constraints, geographic units, and calibration techniques.

19. Goldner, William, Projective Land Use Model, Bay Area Transportation Study Commission Technical Report 219, September 1968.

PLUM, a derivative of Lowry's Model of Metropolis, allocates to geographic subdivisions levels of population and population-serving employment.

19. (Continued)

Residences are allocated on the basis of accessibility to employment. Retail market potentials are generated as a function of household and employment location. The model employs a comparative statics framework, operating recursively over time.

20. Hamilton, H. R., S. E. Goldstone, F. J. Cessario, D. C. Sweet, D. E. Boyce, and A. L. Pugh III, *Final Report on a Dynamic Model of the Economy of the Susquehanna River Basin*, Battelle Memorial Institute, Columbus, Ohio, 1966.

Technical description and analysis of the results of a regional dynamic simulation model. Economic, demographic, and water resources factors are formulated in individual models of multi-county subregions. The primary behavioral relationships are labor force/employment interactions.

21. Hamilton, H. R., S. E. Goldstone, J. W. Milliman, A. L. Pugh III, E. B. Roberts, and A. Zellner, *Systems Simulation for Regional Analysis: An Application to River-Basin Planning*, The M.I.T. Press, Cambridge, Massachusetts, 1969.

A dynamic regional model of the economy of the Susquehanna River Basin. The model simulates employment/labor force interactions in each of several "subregions." The resultant behavior of unemployment and wages affects migration of population and industries into and out of each subregion. Geographic distribution of residents and employment within subregions is not addressed.

22. Hester, James, Jr., *Systems Models of Urban Growth and Development*, M.I.T. Urban Systems Laboratory, Cambridge, Massachusetts, November 1969.

A review of a number of models of urban development and a detailed analysis of Forrester's Urban Dynamics Model. Forrester's formulation is substantially revised in Hester's model, which treats only population and employment. The model's geographic division of an urban area into core city and suburbs remedies a commonly cited deficiency of the Forrester model.

23. Hill, Donald M., "A Growth Allocation Model for the Boston Region," *Journal of the American Institute of Planners*, Volume XXXI, Number 2, pp. 111-120, May 1965.

The EMPIRIC Model was designed to allocate blue- and white-collar population and retail, manufacturing, and other employment to subregions in the Boston Metropolitan Area. Residential and industrial land development is dependent upon numerous exogenous factors: intensities of land use, zoning regulations, accessibilities, quality of water service, and quality of sewerage service. Equations were calibrated using multiple linear regression.

24. Hoover, Edgar M., *The Location of Economic Activity*, McGraw-Hill Book Company, Inc., New York, 1948.

An analytical examination of locational preferences of industry in terms of procurement, processing, and distribution advantages. Political

24. (Continued)

boundaries and public policies are analyzed for their effects on economic location and stability, and trade movements.

25. Isard, Walter, *Methods of Regional Analysis*, M.I.T. Press, Cambridge, Massachusetts, 1960.

A wide range of analytical techniques in regional science are described and evaluated: alternative forms of population projection and migration estimation; regional income estimation; interregional flow analysis; regional cycle and multiplier analysis; industrial location analysis; input-output techniques; interregional linear programming; and gravity and potential models.

26. Kadanoff, Leo P., "An Examination of Forrester's 'Urban Dynamics'," *Simulation*, pp. 261-268, June 1971.

A critical examination of the major variables, structure and policy conclusions of Forrester's Urban Dynamics Model.

27. Kain, John F., "The Journey-To-Work as a Determinant of Residential Location," *Papers and Proceedings of the Regional Science Association*, Vol. 9, pp. 137-160, 1962.

An attempt to explain observed residential distribution by assuming that household location centers around the journey-to-work. Households attempt to minimize total costs, that is, costs of transportation (assumed to increase with distance from workplace), and costs of residential space (assumed to decrease with distance from the workplace). The expected static equilibrium solution is compared with Detroit data on the distribution of households across a series of concentric zones. The model shows no major discrepancies with the observed distribution.

28. Kain, John F., and G. K. Ingram, *The NBER Urban Simulation Model as a Theory of Urban Spatial Structure*, Preliminary Draft, National Bureau of Economic Research, Inc., October 1972.

A dynamic simulation of the interaction of housing supply and demand in urban area housing markets based on Kain's journey-to-work theory. Price and availability of housing and neighborhood characteristics are additional location criteria. The distribution of residential demand is obtained from a linear program which minimizes total travel costs. Supplies of housing are governed by profitability (to landowners and developers) of construction, filtering, and transformation.

29. Kaiser, Edward J., *A Producer Model for Residential Growth*, Center for Urban and Regional Studies, Institute for Research in Social Science, University of North Carolina, Chapel Hill, N.C., November 1968.

A producer oriented model based on discriminant functions and formulated from empirical results obtained for two North Carolina cities. A linear combination

29. (Continued)

of four predictor variables (socio-economic rank, distance to nearest elementary school, index of accessibility to employment areas, and availability of public utilities and services) was used to calculate probabilities of single family, subdivision development. The equation, calibrated from historical data, predicts development with an accuracy of only 52% for small-developer subdivisions, but with 92% accuracy for large-developer subdivisions (random choice is 50%).

30. Kaiser, E. J., R. W. Massie, S. F. Weiss, and J. E. Smith, "Predicting the Behavior of Predevelopment Landowners on the Urban Fringe," Journal of the American Institute of Planners, September 1968.

Multivariate analysis is used to calibrate six predictor variables which determine the probability of landowners selling undeveloped property. Variables are: owner residence on the land; owner employment (vs. retirement); length of ownership; assessed value; type of ownership (single or joint); and amount of contiguous development. Forecasts are more accurate when calibrated for each area of application and for each concentric ring within an area.

31. Kilbridge, M., R. O'Block, and P. Teplity, A Conceptual Framework for Urban Planning Models, Harvard University Graduate School of Business Administration, Boston, Massachusetts, January 1968.

A series of classifications are developed for models of urban form and activity: by subject (land use/population/transportation/economic activity); by function (projection/allocation/derivation); by theory (behavioral/growth forces); and by method (econometric/mathematical programming/simulation).

32. Lakshmanan, T. R., and W. G. Hansen, "A Retail Market Potential Model," Journal of the American Institute of Planners, Vol. 31, No. 2, pp. 134-143, May 1965.

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35. Lowry, Ira S., A Model of Metropolis, RAND Corporation, Santa Monica, California, 1964.

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39. Putman, Stephen H., "Developing and Testing an Intra-Regional Model," Regional Studies, Vol. 4, pp. 473-490, December 1970.

A description of a model integrating portions of the concepts of economic base, intersectoral input-output, and spatial accessibility to forecast employment (by ten sectors), population, personal income (by six classes), land value, and land use for 131 county-sized areas.

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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
A-01	X		X									X		X							X						X	
A-02	X		X			X											X		X						X			
A-03	X		X			X												X	X						X			
A-04	X		X										X		X				X				X					
A-05	X		X					X								X			X					X	X	X		
A-06	X											X							X					X				X
A-07	X	X		X	X										X				X		X			X				
A-08	X		X			X			X								X		X						X			

I. HIGHWAYS

A. Economic

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
A-17	X		X						X						X			X	X					X	X			
A-18	X					X											X		X					X	X			
A-19	X												X		X						X			X				
A-20	X											X			X					X		X						
A-21	X								X						X				X	X			X					
A-22	X	X	X	X									X			X				X		X						
A-23	X								X		X						X		X				X					
A-24	X												X	X							X			X			X	

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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
A-25.	X								X		X							X	X	X		X						
A-26.	X	X	X									X		X							X		X					
A-27.	X								X			X			X			X	X				X		X			
A-28.	X					X												X	X					X	X	X		
A-29.	X		X	X	X		X	X						X		X			X		X			X	X			X
A-30.	X	X	X			X	X	X								X	X		X		X						X	
A-31.	X								X						X					X			X		X			
A-32.	X		X			X			X								X			X				X				

I. HIGHWAYS

A. Economic

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
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I. HIGHWAYS

A. Economic

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
A-50.	X			X	X							X			X				X					X				X
A-51.	X		X						X		X						X		X					X				
A-52.	X	X	X						X							X			X				X		X			
A-53.	X					X										X			X					X	X			
A-54.	X	X	X						X								X		X					X		X		
A-55.	X	X	X			X											X	X	X					X				
A-56.	X	X	X						X									X	X					X	X			
A-57.	X			X									X	X		X					X						X	

I. HIGHWAYS

A. Economic

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
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	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
A-65	X									X								X	X					X	X			
A-66	X					X			X								X		X					X	X			
A-67	X	X							X					X		X			X		X			X		X		
A-68	X		X			X											X	X	X					X	X			X
A-69	X	X										X			X				X				X					
A-70	X											X				X				X			X	X				
A-71	X	X		X	X							X			X				X				X					
A-72	X					X			X								X		X					X				

I. HIGHWAYS

A. Economic

A-73. **Wullweber, L. D.,** Long Term Economic Effects of Highway SD 50 Bypass on Tyndall, South Dakota, South Dakota Department of Highways, 1967.

A-74. Zickefoose, P. W., Raton Bypass Study - After Phase, New Mexico State University, November 1967.

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	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
A-73	X					X											X		X					X				
A-74	X		X			X											X		X					X				
A-75	X											X	X							X			X			X		

I. HIGHWAYS

B. Social and Demographic

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
B-01. Ashford, N., and F. W. Halloway, The Effect of Age on Urban Travel Behavior (Report No. 1), Florida State University Transportation Center, June 1970. NTIS (PB-196-843).	X	X											X			X				X		X						
B-02. Balkus, K., "Transportation Implications of Alternative Sketch Plans," Highway Research Record, Number 180, pp. 52-70, 1967.		X			X										X					X							X	
B-03. Buffington, J. L., D. Burke, W. Adkins, and H. Meuth, Experience and Opinions of Residents Along Elevated, Depressed, and On-Grade Freeway Sections in Houston, Texas - Economic & Environmental Effects as Factors in Highway Decision Making, Texas Transportation Institute, Texas Highway Department, Federal Highway Administration, Report No. 2-1-71-148.		X		X			X									X			X					X				X
B-04. Burkhardt, J. E., "Impact of Highways on Urban Neighborhoods: A Model of Social Change," Highway Research Record, Number 356, pp. 85-94, 1971.	X	X	X									X				X				X		X						
B-05. Christensen, A. G., and A. N. Jackson, "Problems of Relocation in a Major City: Activities and Achievements in Baltimore, Maryland," Highway Research Record, Number 277, pp. 1-8, 1969.	X	X		X								X				X					X						X	
B-06. Clawson, Marion, "Implications of Recreational Needs for Highway Improvement," Highway Research Board, Bulletin 311, pp. 31-37, 1962.		X										X		X						X	X						X	
B-07. Cooper, E., Methods of Improving Transportation Facilities for Inner-City Dwellers, Howard University, 1970. NTIS (PB-196-095).		X		X									X			X			X		X			X			X	
B-08. Dansereau, H. Kirk, "Five Years of Highway Research: A Sociological Perspective," Highway Research Record, Number 75, pp. 76-82, 1965.		X							X								X				X						X	

I. HIGHWAYS

B. Social and Demographic

B-09. Dansereau, H. Kirk, "Highway Development: Community Attitudes and Organization," Highway Research Record, Number 16, pp. 44-59, 1963.

B-10. Ehrlich, T., Specialized Trip Distribution Study: Metropolitan Recreation, Consortium of University, Urban Transportation Center, 1970. NTIS (PB-194-096).

B-11. Ellis, R. H., and R. D. Worrall, "Toward Measurement of Community Impact: The Utilization of Longitudinal Travel Data to Define Residential Linkages," Highway Research Record, Number 277, pp. 25-39, 1969.

B-12. Falcocchio, J., Modal Choices and Travel Attributes of the Inner-City Poor, Polytechnic Institute Brooklyn, September 1971. NTIS (PB-206-149).

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B-14. Goodwin, A., "Attitudes and Shopper Mobility in a Small City," Highway Research Record, Number 233, pp. 16-26, 1968.

B-15. Greytak, D., Residential Segregation, Metropolitan Decentralization and the Journey to Work - Occasional Paper No. 1, Syracuse University, Urban Transportation Institute, July 1970. NTIS (PB-196-904).

B-16. Grier, George W., "Social Impact Analysis of an Urban Freeway System," Highway Research Record, Number 305, pp. 63-74, 1970.

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
B-09		X	X	X			X	X								X			X	X				X				X
B-10		X	X									X				X				X		X						X
B-11		X										X				X				X				X				X
B-12	X	X											X			X					X			X				
B-13	X	X	X									X	X			X			X			X	X					
B-14		X											X			X			X		X			X				X
B-15	X	X											X			X					X						X	
B-16		X		X	X		X		X							X			X								X	

I. HIGHWAYS

B. Social and Demographic

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
B-17. Hinshaw, M., and K. Allott, "Environmental Preferences of Future Housing Consumers," Journal of the American Institute of Planners, Vol. 38, No. 2, pp. 102-107, March 1972.		X											X			X				X	X		X					
B-18. Hyman, G. M., "Trip Distribution and Modal Split by Categories of Households," Transportation Research, Vol. 4, No. 1, pp. 71-76, April 1970.		X											X							X		X						
B-19. Kalachek, E. D. and J. M. Goering, Transportation and Central City Unemployment, Washington University, St. Louis, March 1970. NTIS (PB-192-493).	X	X											X			X			X					X				X
B-20. Kanwit, Edmond L., andA. F. Eckartt, "Transportation Implications of Employment Trends in Central Cities and Suburbs," Highway Research Record, Number 187, pp. 1-14, 1967.		X											X			X			X		X			X				
B-21. Koike, H., Planning Urban Transportation Systems: A Model for Generating Socially Desirable Transportation Network Configurations - Research Report No. 2, Washington University, Seattle Urban Planning and Civil Engineering Departments. NTIS (PB-199-290).	X	X											X			X				X		X						
B-22. Kurkhardt, J. E., and M. T. Shaffer, "Social and Psychological Impacts of Transportation Improvements," Transportation (NETH), Vol. 1, No. 2, pp. 207-226, August 1972.		X											X			X				X	X						X	
B-23. Lisco, T. E., "Value of Commuters Travel Time - A Study in Urban Transportation," Highway Research Record, Number 245, p. 36, 1968.	X	X											X			X			X				X	X				X
B-24. Manarolla, J. A., The Trip to Work - A Submodule of a General Metropolitan-Regional Area Man-Machine Simulation, Consortium of University, Urban Transportation Center, 1970. NTIS (PB-196-099).	X	X	X										X		X	X				X		X						

I. HIGHWAYS

B. Social and Demographic

B-25. McKain, W. C., "Community Response to Highway Improvements," Highway Research Record, Number 96, pp. 19-23, 1965.

B-26. McLean, E. L., and W. G. Adkins, "Freeway Effects on Residential Mobility in Metropolitan Neighborhoods," Highway Research Record, Number 356, pp. 95-104, 1971.

B-27. Meyburg, A. H., "Analysis of Relationships Between Intercity Passenger Transportation and the Socio-economic Characteristics of Metropolitan Areas," Transportation Research Forum, Vol. 13, No. 1, pp. 271-284, 1972.

B-28. Mouchahoir, G. E., The Relationship of Work Trips to Employment Connected Social and Economic Factors, 1970. NTIS (PB-191-816).

B-29. Mouchahoir, G. E., and P. H. Wright, "Use of Socioeconomic Indicators in Trip Attraction of Large Work Centers," Highway Research Record, Number 392, pp. 139-142, 1972.

B-30. Nash, W., and J. Voss, "Analyzing the Socio-Economic Impact of Urban Highways," Highway Research Board, Bulletin 268, pp. 80-94, 1960.

B-31. Redding, M. J., and G. L. Peterson, "Adequacy of the Spatial Organization of Residential Neighborhoods: The Residents' Point of View," Highway Research Record, Number 410, pp. 64-65, 1972.

B-32. Ryan, C. R., et al., "An Evaluation of the Feasibility of Social Diagnostic Techniques in the Transportation Planning Process," Highway Research Record, Number 410, pp. 8-21, 1972.

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
B-25		X		X					X									X	X					X				X
B-26		X										X				X				X						X		
B-27	X	X											X			X			X				X					
B-28	X	X											X			X			X	X		X						
B-29	X	X											X			X			X	X		X						X
B-30	X	X	X	X								X				X			X								X	
B-31		X										X					X			X		X						
B-32		X										X				X			X					X				X

I. HIGHWAYS

B. Social and Demographic

B-33. Sawhill, Roy, Freeways and Residential Neighborhoods, Automotive Safety Foundation, Washington, D. C., 1965.

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B-36. Smith, Wilbur & Associates, Inc., The Impact of Highways on Selected Public Services, prepared for the U.S. Department of Commerce, Bureau of Public Roads, New Haven, Connecticut, 1960.

B-37. Stegman, Michael, "Accessibility Models and Residential Location," Journal of the American Institute of Planners, Vol. 37, No. 2, pp. 100-110, March 1971.

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B-41. Thomas, T. C., G. I. Thompson, and S. Reichman, "Value of Time Saved by Trip Purpose with Discussion and Closure," Highway Research Record, Number 369, pp. 104-117, 1971.

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
B-33		X	X													X			X					X				
B-34		X	X										X				X			X			X					
B-35		X											X			X			X								X	
B-36		X		X								X		X	X	X			X					X				
B-37		X												X					X		X		X					X
B-38	X	X	X	X								X					X				X			X				
B-39	X	X										X				X					X			X				
B-40		X											X							X		X						
B-41		X											X							X		X						

I. HIGHWAYS

B. Social and Demographic

B-42. **Ueberschaer, M. H.**, "Choice of Routes on Urban Networks for the Journey to Work," Highway Research Record, Number 369, pp. 228-238, 1971.

B-43. Wachs, Martin, "Basic Approaches to the Measurement of Community Values," Highway Research Record, Number 305, 1970.

B-44. Watson, P. L., "Problems Associated with the Time and Cost Data Used in Travel Choice Modeling and Valuation of Time," Highway Research Record, Number 369, pp. 148-158, 1971.

B-45. Wheeler, J. O., "Transport Inputs and Residential Rent Theory: An Empirical Analysis," Geographical Analysis, Vol. 2, No. 1, pp. 43-54, January 1970.

B-46. Wildermuth, Bruno, The Effect of Transportation on Residential Location, Graduate Report, Institute of Transportation and Traffic Engineering, University of California, April 1964.

B-47. Wilson, A. G., "The Use of Entropy Maximizing Models in the Theory of Trip Distribution, Mode Split and Route Split," Journal of Transport Economics and Policy, Vol. 3, No. 1, pp. 108-126, January 1969.

B-48. Yapa, L., M. Polese, and J. Wolpert, "Interdependencies of Commuting, Migration, and Job Site Relocation," Economic Geography, Vol. 47, No. 1, pp. 59-72, January 1971.

B-49. Zupan, J. M., "Mode Choice: Implications for Planning," Higaway Research Record, Number 251, pp. 6-25, 1968.

B-50. Hill, Stuart L., and B. Frankland, "Mobility as a Measure of Neighborhood," Highway Research Record, Number 187, pp. 33-42, 1967.

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
B-42		X										X				X			X			X		X				X
B-43		X											X			X				X				X				
B-44		X											X							X		X						
B-45		X											X			X					X		X					
B-46		X											X							X							X	
B-47		X											X							X		X						
B-48		X											X		X					X		X						
B-49		X		X									X							X		X						
B-50		X										X					X			X				X				

I. HIGHWAYS

C. Land Use and Land Value

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
C-01. Adkins, W. G., "Land Value Impacts of Expressways in Dallas, Houston, and San Antonio, Texas," Highway Research Board, Bulletin 227, pp. 50-65, 1959.			X				X									X			X					X				
C-02. Adkins, William G., J. E. Frierson, and R. H. Thompson, Farm Land Values and Rural Road Service in Ellis County, Texas 1955-58, Texas Transportation Institute, Texas A & M College, College Station, Texas, June 1960.		X	X							X								X	X				X					X
C-03. Ashley, R. H., and Berard, W. F., "Interchange Development Along 187 Miles of I-94," Highway Research Record, Number 96, pp. 46-58, 1965.	X		X						X		X								X					X				
C-04. Bahl, R. W., Jr., A Bluegrass Leapfrog, Bureau of Business Research, College of Commerce, University of Kentucky, 1961.	X		X									X				X			X			X						
C-05. Barden, R., and J. H. Thompson, The Urban Frontier - Occasional Paper No. 4, Syracuse University, Urban Transportation Institute, 1971. NTIS (PB-204-558).			X				X									X						X						
C-06. Borchert, John R., Beltline Commercial-Industrial Development - A Case Study in the Minneapolis-St. Paul Metropolitan Area, University of Minnesota, Minneapolis, Minnesota, November 1960.	X		X	X				X								X			X					X				
C-07. Brand, D., B. Barber, and M. Jacobs, "Technique for Relating Transportation Improvements and Urban Development Patterns," Highway Research Record, Number 207, pp. 53-67, 1967.	X		X										X			X				X		X						
C-08. Carroll, Donald D., J. R. Borchert, J. Schwinder, and P. M. Raup, The Economic Impact of Highway Development Upon Land Use and Value: Development of Methodology and Analysis of Selected Highway Segments in Minnesota, University of Minnesota, Sept. 1958.	X		X			X	X									X			X	X				X				

I. HIGHWAYS

C. Land Use and Land Value

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
C-09. **Cherner, M.**, "Property Values as Affected by Highway Landscape Developments," Highway Research Record, Number 53, pp. 4-7, 1964.	X	X	X				X									X			X					X				X
C-10. Cockfield, a. W., "Proposed Logic Sequence for Designing Preliminary Urban Land Use Plans," Highway Research Record, Number 399, pp. 62-70, 1972.			X										X							X			X					
C-11. Cribbins, P. D., W. T. Hill, and H. O. Seagraves, "Economic Impact of Selected Sections of Interstate Routes on Land Value and Use," Highway Research Record, Number 75, pp. 1-31, 1965.			X			X			X							X		X	X					X				
C-12. Davis, J. Tait, "Parkways, Values and Development in the Washington Metropolitan Region," Highway Research Record, Number 16, pp. 32-43, 1963.	X	X	X	X		X										X			X			X						
C-13. Eighmy, T. H., and J. J. Coyle, Toward a Simulation of Land Use for Highway Interchange Communities, Pennsylvania State University, 1965.	X		X								X									X		X						
C-14. Evans, E. E., Impact of Kokomo By-Pass, 1950 to 1964, Purdue University, August 1965.			X			X										X					X						X	
C-15. Everly, R. W., Property Formation, Real Estate Value, and Land Use in Four York County Interchange Communities: An Interim Report, Pennsylvania State University, 1965.			X								X					X			X					X				
C-16. Flaherty, M. C., "Commercial Highway Service Districts and the Interstate," Highway Research Record, Number 96, Washington, D.C., 1965.	X		X								X						X			X							X	
C-17. Fleischman, E. R., The Impact After Seven Years of a Highway Improvement in a Small City, Purdue University, 1968.			X																		X						X	

I. HIGHWAYS

C. Land Use and Land Value

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
C-18. Garrison, William L., and M. E. Marts, Influence of Highway Improvements on Urban Land - A Graphic Summary, University of Washington, May 1958.	X	X	X									X									X		X					
C-19. Goldberg, M., "Transportation, Urban Land Values, and Rents: A Synthesis," Land Economics, Vol. 46, No. 2, pp. 153-162, May 1970.	X		X										X							X							X	
C-20. Goldberg, M., "Economics of Transportation Corridors: Further Empirical Analysis," Highway Research Record, Number 410, pp. 37-51, 1972.	X		X										X			X			X				X					
C-21. Goldberg, M., "An Evaluation of the Interaction Between Urban Transport and Land Use Systems," Land Economics, Vol. 48, pp. 338-346, 1972.	X		X										X			X					X						X	
C-22. Golden, J. S., "Land Values in Chicago: Before and After Expressway Construction," Chicago Area Transportation Study, 65 pp., October 1968.			X									X				X			X				X		X	X		
C-23. Hamburg, J. R., G. J. Brown, and M. Schneider, "Impact of Transportation Facilities on Land Development," Highway Research Record, Number 305, pp. 172-178, 1970.			X										X							X		X						
C-24. Hammel, L. V., K. C. Maffitt, and R. R. Roberts, "Transportation Considerations of Regional Shopping Centers," Traffic Engineering, Inst. Traffic Engineering, Vol. 42, No. 11, pp. 14-21, August 1972.			X										X								X						X	
C-25. Harvey, Robert O., and W. A. V. Clark, "The Nature and Economics of Urban Sprawl," Land Economics, Vol. 71, pp. 1-9, February 1965.	X		X	X									X			X					X						X	

I. HIGHWAYS

C. Land Use and Land Value

C-26. Huhtanen, Robert J., et al., A Study of the Effects of Freeways on Central Business Districts, Clark University, Worcester, Massachusetts, February 1961.

C-27. Isard, W., and P. Liossatos, "On Location Analysis for Urban and Regional Growth Situations," Annals of Regional Science, Vol. 6, No. 1, pp. 1-27, June 1972.

C-28. Isibor, E. I., Modeling the Impact of Highway Improvements on the Value of Adjacent Land Parcels, Purdue University, Indiana State Highway Commission, 1970.

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C-31. Lehr, R. L., Relationship of the Highway Interchange and the Use of Land in the State of Oklahoma, Oklahoma Center of Urban and Regional Studies, June 1965. NTIS (PB-172-988).

C-32. Lemly, J. H., "Changes in Land Values Along Atlanta's Expressway," Highway Research Board, Bulletin 227. pp. 1-20, 1959.

C-33. Lemly, J. H., Expressway Influence on Land Use and Value, Atlanta 1941-1956, Georgia State College, School of Business Administration, Bureau of Business and Economic Research, 1958.

C-34. Lewis, J. E., "Transportation Theory of Urban Land Rent," Right of Way, Vol. 9, No. 2, pp. 23-28, April 1972.

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
C-26.		X	X									X				X			X					X				X
C-27.			X										X							X		X						
C-28.			X									X								X		X						
C-29.	X		X					X								X			X					X				X
C-30.	X		X			X										X			X					X				
C-31.	X		X								X					X			X		X			X			X	
C-32.	X		X	X			X									X			X					X		X		
C-33.	X		X				X									X			X					X		X		
C-34.	X	X	X										X			X					X						X	

I. HIGHWAYS

C. Land Use and Land Value

C-35. Long, G. A., G. D. Long, and R. W. Hooker, A Corridor Land Use Study: The Impact of an Interstate Highway on Land Use Values, Private Investment and Land Use in Southwestern Wyoming, Wyoming University, FHWA, October 1972.

C-36. Massachusetts Department of Commerce and Development, Future Development of Eastern Massachusetts Route 495 and Fringe Area, 1963 and 1975-1990, Boston, Massachusetts, 1967.

C-37. Milgram, Grace, The City Expands: A Study of the Conversion of Land from Rural to Urban Use, Philadelphia 1945-1962, University of Pennsylvania, Institute for Environmental Studies, March 1967.

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C-40. O'Flaherty, C. A., "People, Transport Systems, and the Urban Scene: An Overview - 1," Intl. J. Environmental Studies, Vol. 3, No. 3, pp. 265-285, July 1972.

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	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
C-35			X						X						X				X					X				
C-36	X	X	X	X				X								X			X			X						
C-37			X										X			X			X				X				X	
C-38			X	X							X					X		X			X			X			X	
C-39			X						X							X			X								X	
C-40		X	X										X			X					X						X	
C-41			X	X					X		X					X			X		X			X			X	

I. HIGHWAYS

C. Land Use and Land Value

	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
C-42. Pendleton, W. C., "Relation of Highway Accessibility to Urban Real Estate Values," Highway Research Record, Number 16, pp. 14-23, 1963.	X	X	X				X									X			X				X					
C-43. Philbrick, Allen, Analyses of the Geographical Patterns of Gross Land Uses and Changes in Numbers of Structures in Relation to Major Highways in the Lower Half of the Lower Peninsula of Michigan, Michigan State University, 1961.	X		X									X			X					X								X
C-44. Rockey, Melvin B., and J. C. Frey, Farms and New Highways: Problems and Adjustments, Pennsylvania State University, University Park, Pennsylvania, 1964.	X	X	X	X					X									X						X				
C-45. Rogers, Andrei, The Time Lag of Factors Influencing Land Development, (in collaboration with F. S. Chapin, Jr., T. G. Donnelly, and S. F. Weiss), Institute for Research in Social Science, University of North Carolina, Chapel Hill, N.C., October 1963.			X										X			X				X		X						
C-46. Sauerlender, O. H., and R. B. Donaldson, Predicting Development at Non-Urban Interchange Sites on Pennsylvania Interstate Highways, Pennsylvania State University, 1965.		X	X								X						X			X		X						
C-47. Schmidt, Blaine G., Delaware Highway Impact Study, Phase II Report (1959-1963), Bureau of Economic and Business Research, University of Delaware, 1967.	X		X	X					X																X	X		
C-48. Schneider, M., "The Access and Development Prototype Project," Highway Research Record, Number 293, pp. 147-154, 1969.			X										X							X		X						

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C. Land Use and Land Value

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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
C-49	X	X	X						X	X	X					X			X					X				
C-50	X	X	X								X					X		X					X	X				
C-51			X	X									X			X						X						
C-52			X										X							X		X	X					
C-53			X	X							X						X				X			X			X	
C-54	X	X	X	X								X									X			X				
C-55	X		X						X							X			X				X		X	X		
C-56			X										X							X	X	X					X	

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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
D-01	X	X		X								X				X			X		X	X					X	
D-02				X									X			X			X								X	
D-03		X	X	X									X			X					X	X						
D-04			X	X							X										X						X	
D-05		X		X								X				X				X							X	
D-06				X								X				X					X						X	
D-07	X	X	X	X									X				X			X				X				
D-08	X	X		X								X				X			X					X				

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D. Political-Legal

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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
D-09	X			X									X			X				X		X	X				X	
D-10		X	X	X					X							X				X		X					X	
D-11		X		X								X					X				X			X			X	
D-12				X								X					X			X				X				
D-13	X	X	X	X			X									X			X					X			X	
D-14		X	X	X				X								X			X	X							X	
D-15	X		X	X					X			X				X		X	X					X				X
D-16	X	X		X					X			X				X					X						X	

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	IMPACTS				INVESTMENT TYPE									AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Network	Bypass	Radial	Circumferential	Interstate	Secondary	Interchange	Highways, General	Transportation, General	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
D-17	X	X		X	X										X						X						X	
D-18			X	X									X			X					X						X	
D-19			X	X					X		X				X				X					X				
D-20	X	X	X	X									X			X			X		X						X	
D-21			X	X	X											X			X		X						X	
D-22	X	X		X								X									X						X	
D-23		X	X	X								X				X				X							X	
D-24	X	X		X									X							X							X	

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IMPACTS				INVESTMENT TYPE				AREA				STUDY TYPE			METHODOLOGY						
Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Rail Facilities	Bus Facilities	Public Transit, General	Transportation, General	National	Regional	Metropolitan	Local	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
	X					X							X		X						
	X					X				X		X			X						
	X					X				X		X			X						
	X				X					X		X					X				
		X				X				X			X			X		X	X		
		X	X	X						X		X			X	X					
X	X				X					X		X					X				
X	X			X						X		X								X	

II. MASS TRANSIT

	IMPACTS				INVESTMENT TYPE				AREA				STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Rail Facilities	Bus Facilities	Public Transit, General	Transportation, General	National	Regional	Metropolitan	Local	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
09. Colcord, F. C., Urban Transportation Decision Making: Houston, A Case Study, 1970. NTIS (PB-206-224).				X			X	X			X		X								X	
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14. Gannon, Colin A., et al., The Impact of Rail Rapid Transit Systems on Commercial Office Development: The Case of the Philadelphia Lindenwold Speedline, University of Pennsylvania, June 1972.	X	X	X		X						X	X	X				X				X	
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16. Greytak, D., Residential Segregation, Metropolitan Decentralization of the Journey to Work - Occasional Paper No. 3, Syracuse University, Urban Transportation Institute, July 1970. NTIS (PB-196-904).	X	X					X	X			X				X						X	

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	IMPACTS				INVESTMENT TYPE				AREA				STUDY TYPE			METHODOLOGY						
	Economic	Social/Demographic	Land Use & Land Value	Political/Legal	Rail Facilities	Bus Facilities	Public Transit, Capital	Transit Operating, General	National	Regional	Metropolitan	Local	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
17.	X						X	X			X		X			X						
18.							X							X	X	X						
19.	X	X	X	X	X						X		X					X				
20.	X	X	X	X	X						X		X					X			X	
21.	X							X			X			X	X	X	X				X	
22.	X	X					X	X			X		X					X				X
23.	X	X					X				X			X		X						
24.	X	X						X			X			X		X						

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	IMPACTS				INVESTMENT TYPE				AREA				STUDY TYPE			METHODOLOGY						
	Economic	Social/Demographic	Land Use & Land Value	Political/Legal	Rail Facilities	Bus Facilities	Public Transit, General	Transportation, General	National	Regional	Metropolitan	Local	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
25.		X						X			X			X	X						X	
26.			X	X	X						X		X	X				X				
27.		X					X				X				X						X	
28.	X		X					X							X						X	
29.	X	X			X						X		X				X	X				X
30.	X			X			X				X		X	X							X	
31.	X	X		X				X		X	X			X		X						
32.	X	X					X	X		X			X				X					

II. MASS TRANSIT

	IMPACTS				INVEST-MENT TYPE				AREA				STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Rail Facilities	Bus Facilities	Public Transit, General	Transportation, General	National	Regional	Metropolitan	Local	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
42. Simpson and Curtin, The Traffic Rider, 1968; Interim Report No. 1, 1966. NTIS (PB-195-838).		X				X					X		X					X				
43. Skidmore, Owings & Merrill, Center City Transportation Project: Urban Design Guideline, September 1970. NTIS (PB-198-600).		X						X			X		X								X	X
44. Stanford Research Institute, Future Urban Transportation Systems: Impacts on Urban Life and Form-Final Report II, Menlo Park, California, March 1968. NTIS (PB-178-266).	X	X					X				X				X						X	
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47. Teska, R. B., "Social, Economic, and Environmental Impacts of A System of High-Accessibility Corridors," Highway Research Record, Number 356, pp. 119-129, 1971.			X	X				X			X		X		X						X	
48. Tuzo, G. C., The Evolution of the D.C. Highway System, Consortium of University, Urban Transportation Center, June 1971. NTIS (PB-204-935).	X		X	X				X			X		X		X						X	
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	IMPACTS				INVEST-MENT TYPE				AREA				STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Rail Facilities	Bus Facilities	Public Transit, General	Transportation, General	National	Regional	Metropolitan	Local	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
33.	X	X	X	X				X			X				X			X			X	
34.		X		X	X						X		X								X	
35.	X	X				X		X			X			X		X						
36.			X					X			X				X						X	
37.	X	X	X	X			X	X	X						X						X	
38.	X	X		X			X	X			X				X						X	
39.	X						X			X			X			X						
40.	X	X	X	X	X					X			X				X					
41.	X	X	X	X	X	X	X			X	X		X		X			X				

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	IMPACTS				INVEST-MENT TYPE				AREA				STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Rail Facilities	Bus Facilities	Public Transit: General	[illegible]	National	Regional	Metropolitan	Local	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Descriptive	[illegible]	Qualitative	Other
50.	X						X				X		X					X				
51.	X	X		X			X	X						X							X	
52.	X	X						X	X						X		X				X	

III. WASTEWATER FACILITIES

	IMPACTS						AREA					STUDY TYPE			METHODOLOGY						
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Treatment Facility	Collection Facility	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
01	X		X	X	X	X			X					X						X	
02	X	X	X	X	X	X		X						X						X	
03			X		X			X						X						X	
04	X	X	X			X		X	X			X				X					
05			X	X	X	X		X	X			X					X				
06			X		X	X			X			X				X				X	
07			X		X	X		X				X					X				
08		X		X	X	X			X				X			X					

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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	Treatment Facility	Collection Facility	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Model	Statistical Analysis	Data Measurement	Before/After	Study/Control Area	Qualitative	Other
09.			X	X	X	X		X	X			X					X				
10.	X	X	X	X	X	X		X	X			X					X				
11.			X		X	X		X				X					X				
12.			X	X	X	X		X				X					X				
13.	X		X	X	X	X		X				X					X				
14.			X		X	X		X	X			X					X				
15.	X			X	X	X		X				X					X				

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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Simulation Model	Econometric Model	Other Model	Statistical Analysis
01.	X	X		X			X				X	X				X
02.	X	X	X				X				X		X		X	
03.	X	X				X				X	X		X			
04.		X	X				X			X						X
05.			X								X		X	X		X
06.	X	X	X			X				X	X		X			
07.			X		X						X					X
08.	X	X	X		X								X	X		

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	IMPACTS				AREA					STUDY TYPE			METHODOLOGY			
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Simulation Model	Econometric Model	Other Model	Statistical Analysis
09	X	X	X				X			X	X		X			
10	X	X	X				X				X				X	
11		X	X					X				X				
12	X	X	X	X			X			X	X		X	X		
13	X	X	X			X				X	X		X			
14	X	X	X	X			X				X	X	X			
15	X	X	X	X			X					X	X			
16	X	X	X	X			X			X	X		X			

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	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Policy Analysis	Simulation Model	Econometric Model	Other Model	Statistical Analysis
17.	X		X				X			X	X		X	X		
18.	X	X	X				X				X	X	X		X	
19.	X	X	X				X				X				X	
20.	X	X				X				X	X		X			
21.	X	X				X				X	X		X			
22.	X	X	X				X				X	X	X			
23.	X	X	X				X			X	X			X		X
24.	X		X									X				X
25.		X				X					X	X			X	X
26.	X	X	X	X			X					X	X			

IV. MODELS

	IMPACTS				AREA					STUDY TYPE			METHODOLOGY			
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Simulation Model	Econometric Model	Other Model	Statistical Analysis
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	IMPACTS				AREA					STUDY TYPE			METHODOLOGY			
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Simulation Model	Econometric Model	Other Model	Statistical Analysis
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37. Lowry, Ira S., "A Short Course in Model Design," Journal of the American Institute of Planners, Vol. 31, No. 2, pp. 158-166 May 1965.	X	X	X			X					X		X	X	X	
38. Markland, Robert E., and P. J. Grandstaff, "Analyzing Urban Economic Change Using Computer Simulation," Proceedings of the 1973 Summer Computer Simulation Conference, Montreal, Canada, July 1973.	X	X					X			X	X		X			
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42. Putman, Stephen H., Preliminary Results from an Integrated Transportation and Land Use Models Package, Draft, University of Pennsylvania, August 1972 (Revised January 1973).	X	X	X				X				X		X		X	
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	IMPACTS				AREA					STUDY TYPE			METHODOLOGY			
	Economic	Socio-Demographic	Land Use & Land Value	Political-Legal	National	Regional	Metropolitan	Local	Rural	Case Study	Methodology Development	Impact Analysis	Simulation Model	Econometric Model	Other Model	Statistical Analysis
44.	X	X	X	X			X			X	X		X			
45.	X	X	X			X					X		X	X	X	X
46.	X	X	X				X				X		X		X	
47.	X	X				X	X			X	X		X			
48.	X	X	X				X					X				
49.	X					X						X				X
50.	X	X	X				X			X	X					X
51.	X	X	X				X			X	X	X	X	X	X	
52.	X					X						X				